(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 October 2002 (10.10.2002)

PCT

(10) International Publication Number
WO 02/078767 A2

(51) International Patent Classification[7]: A61M

(21) International Application Number: PCT/US02/09657

(22) International Filing Date: 28 March 2002 (28.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/821,297 29 March 2001 (29.03.2001) US
09/940,402 27 August 2001 (27.08.2001) US

(71) Applicant *(for all designated States except US)*: **ENDIUS INCORPORATED** [US/US]; 23 West Bacon Street, Plainville, MA 02762 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **PAGLIUCA, James, J.** [US/US]; 184 Village Street, Millis, MA 02054 (US). **UNGER, John, D.** [US/US]; 20 Farm Hill Road, Wrentham, MA 02093 (US).

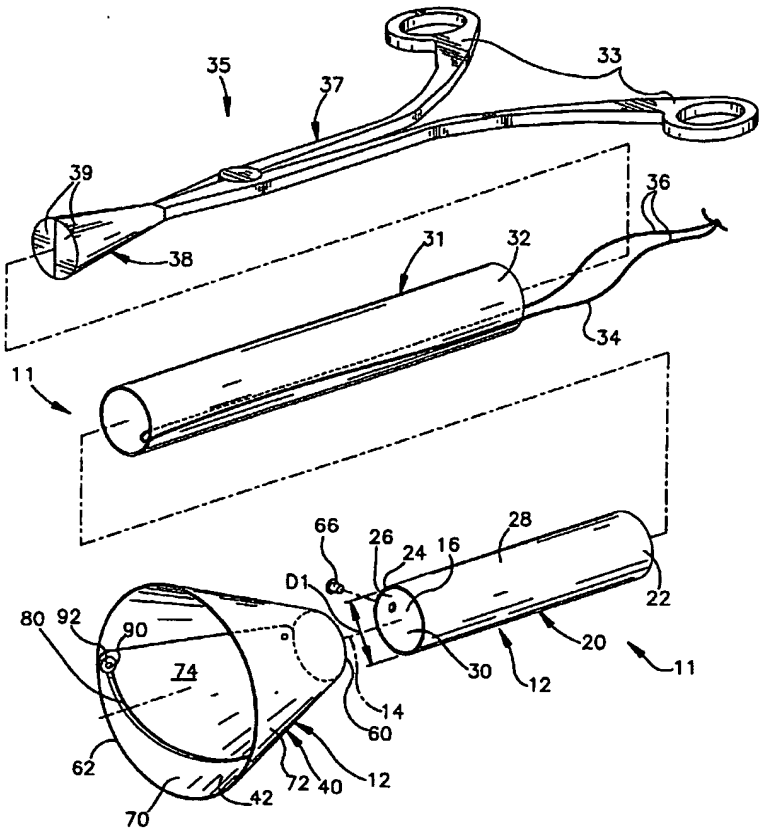
(74) Agent: **TAROLLI, Thomas, L.**; Tarolli, Sundheim, Covell, Tummino & Szabo, 526 Superior Avenue, Suite 1111, Cleveland, OH 44114 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: APPARATUS FOR ADJUSTABLY SUPPORTING AN ENDOSCOPE



(57) Abstract: An apparatus (10) supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The apparatus (10) includes a base (118), a part (140) adapted to be fixed to the endoscope, and a screw mechanism (160). The base (118) has a guide portion (128). The part (140) engages the guide portion (128) and is movable relative to the guide portion (128). The screw mechanism (160) connects between the base (118) and the part (140). At least a portion (610) of the screw mechanism (160) is threated into the base (118) and is rotatable to slide the part (140) relative to the guide portion (128) to change a position of the endoscope relative to the patient. In another feature of the apparatus (10), the apparatus (10) may include a cannula clamp (180) secured to a cannula (11) and rotatable relative to the part (140).

WO 02/078767 A2

European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

APPARATUS FOR ADJUSTABLY SUPPORTING AN ENDOSCOPE

Technical Field

The present invention relates to an apparatus for supporting an endoscope and, more particularly, for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient.

Background of the Invention

Percutaneous surgery is a procedure in which surgical instruments, and typically an endoscope, are inserted through a cannula into the body of a patient. A viewing element, typically a small video camera, is part of the endoscope and is connected to a television monitor so that the surgeon may view the surgical site.

The cannula is a hollow tube. The cannula is inserted through an incision into the body of a patient. The instruments and the endoscope are inserted through the cannula. The cannula also allows

the instruments and endoscope to be removed from the body and/or adjusted in the body during the surgery.

A conventional apparatus for supporting the endoscope allows a surgeon to manipulate the surgical instruments without also moving the endoscope. Also, a known support apparatus allows adjustment of the endoscope relative to the cannula for viewing different areas at the surgical site.

Another conventional apparatus, illustrated by U.S. Patent No. 6,361,488 to Davison et al., provides support for an endoscope during a surgical procedure. In the apparatus of U.S. Patent No. 6,361,488, an adjustment of the endoscope could accidentally occur should a surgeon accidentally apply force to part of the apparatus during the surgical procedure. An endoscopic support apparatus that is less likely to have an accidental endoscope adjustment is desirable.

Summary of the Invention

In accordance with one feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The apparatus includes a base, a part adapted to be fixed to the endoscope, and a screw

mechanism. The base has a guide portion. The part engages the guide portion and is movable relative to the guide portion. The screw mechanism connects the base and the part. At least a portion of the screw mechanism is threaded into the base and is rotatable to slide the part relative to the guide portion to change a position of the endoscope relative to the patient.

In accordance with another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The endoscope extends through a cannula into the patient. The apparatus includes a base, a support mechanism for supporting the endoscope on the base, a cannula clamp, and a connection between the base and the cannula clamp. The cannula clamp clamps against an outer surface of the cannula. The connection enables the base to rotate relative to the cannula clamp about an axis of the cannula. The connection includes an index mechanism with parts interposed between the base and the cannula clamp for retaining the base at incremental relatively rotated positions relative to the cannula clamp.

In accordance with still another feature of the present invention, an apparatus is associated with an

endoscope for viewing a surgical site in a patient during surgery on the patient. The endoscope extends through a cannula into the patient. The apparatus includes a cannula clamp and an actuator. The base supports the endoscope. The cannula clamp includes a pair of arms for clamping against an outer surface of the cannula through which the endoscope extends. The actuator moves the arms a predetermined distance toward each other to effect clamping against the cannula. The cannula clamp further includes an adjustment mechanism for changing the relative position of the arms from which the arms are moved by the actuator to enable the arms to clamp different diameter cannulas.

In accordance with yet another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The apparatus includes a part for engaging the endoscope. The part has a first surface portion for engaging an external surface of the endoscope and a second surface portion spaced apart from the first surface portion for engaging an outer surface of the endoscope defining a light port.

In accordance with still another feature of the present invention, an apparatus supports an endoscope

for viewing a surgical site in a patient during surgery on the patient. The apparatus includes a base, a first part, a second part, and a mechanism for enabling axial and rotational adjustment of the first part relative to the second part. The base is for supporting the endoscope. The first part is adapted to be fixed to the endoscope. The second part is adapted to be fixed to a cannula with a longitudinal axis. The mechanism includes a member supported on the base for rotation relative to the base about an axis parallel to the longitudinal axis of the cannula and spaced apart from the longitudinal axis of the cannula.

In accordance with yet another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The apparatus includes a cannula for insertion into the patient, a cannula clamp, a base, and a part supported for linear movement on the base relative to the base. The cannula clamp engages an outer surface of the cannula. The base is supported for rotation relative to the cannula clamp about a longitudinal axis of the cannula. The part is adapted to be fixed to the endoscope. The part moves in a path parallel to the longitudinal axis of the cannula.

In accordance with still another feature of the present invention, an apparatus supports an endoscope that extends through a cannula for viewing a surgical site in a patient during surgery on the patient. The apparatus includes a base, a first part, a second part, and mechanism. The base is associated with the cannula and has a guide portion. The first part is adapted to be fixed to the endoscope. The second part engages the guide portion and is movable relative to the guide portion. The first and second parts are movable together relative to the guide portion. The mechanism is connected between the base and the second part for moving the first and second parts relative to the guide portion to change a position of the endoscope relative to the patient.

In accordance with yet another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The endoscope extends through a cannula into the patient. The apparatus includes a base and a cannula retainer. The cannula retainer engages an outer surface of the cannula to secure the cannula to the cannula retainer. The cannula retainer includes a split ring for engaging a groove on the

outer surface of the cannula and a sleeve for receiving the cannula and supporting the split ring. The base is rotatable relative to the sleeve about an axis of the cannula.

In accordance with still another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The endoscope extends through a cannula into the patient. The apparatus includes a base, a sleeve, and a sleeve retainer. The base supports the endoscope. The sleeve engages an outer surface of the cannula. The base and sleeve are relatively rotatable about an axis of the cannula. The sleeve retainer supports the sleeve and the base. The sleeve retainer includes a member press fit onto an end portion of the sleeve.

In accordance with yet another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The endoscope extends into a cannula and into the patient. The apparatus includes a base, a sleeve, and a support arm. The base supports the endoscope. The sleeve engages an outer surface of the cannula. The base and sleeve are relatively rotatable

about an axis of the cannula. The support arm secures the sleeve to a support structure. The support arm includes a first portion for connection to the sleeve and a second portion for interconnecting the first portion and the support structure. The first portion comprises an electrically insulating material electrically insulating the sleeve from the second portion.

In accordance with still yet another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The apparatus includes a base, a first part to be fixed to an endoscope, a second part, a screw mechanism, and a pin. The base has a guide portion. The second part is movable in the guide portion and connected with the first part. The first and second parts are movable together relative to the guide portion. The screw mechanism is connected to the second part and is operable to move the first and second parts relative to the guide portion. The pin secures the second part to the screw mechanism. The pin is press fit into recesses in both the second part and the screw mechanism.

In accordance with yet another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The endoscope extends through a cannula into the patient. The apparatus includes a base and a sleeve. The base supports the endoscope. The sleeve engages an outer surface of the cannula. The base and sleeve are relatively rotatable about an axis of the cannula. The sleeve has an internal diameter that increases from an initial diameter as the cannula is inserted into the sleeve and that subsequently springs back toward the initial diameter so that the sleeve grips the cannula.

In accordance with still another feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient during surgery on the patient. The apparatus includes a base, a structure, and a screw mechanism. The base has a guide portion. The structure is adapted to be fixed to the endoscope. The structure engages the guide portion and is movable relative to the guide portion. The screw mechanism is connected between the base and the structure. At least a portion of the screw mechanism is rotatable to slide the structure relative to the

guide portion to change a position of the endoscope relative to the patient. The screw mechanism includes a first threaded spindle having female threads and a second threaded spindle rotatable about an axis relative to the female threads in the first threaded spindle. The first threaded spindle has a lip portion for limiting axial displacement of the first threaded spindle relative to the second threaded spindle.

In accordance with a further feature of the present invention, an apparatus supports an endoscope for viewing a surgical site in a patient through a cannula defining an axis and at least partially disposed within the patient. Such endoscope is configured to extend within an interior portion of the cannula. The apparatus includes a base, a part adapted for mounting to the endoscope, and an axial adjustment mechanism. The base has a guide portion and defines an aperture therethrough for communication with the interior portion of the cannula positioned adjacent to the base. The part adapted for mounting to the endoscope engages the guide portion and is movable relative to the guide portion. The axial adjustment mechanism is positioned between the base and the part. At least a portion of the axial adjustment mechanism is

rotatable to effect movement of the part relative to the guide portion and to thereby axially move the endoscope mounted to the part relative to the aperture in the base.

Brief Description of the Drawings

The foregoing and other features of the present invention will become more apparent to one skilled in the art upon consideration of the following description of the invention and the accompanying drawings, in which:

Fig. 1 is an exploded schematic view illustrating an expandable cannula constructed for use with the present invention;

Fig. 2 is a perspective view of the cannula of Fig. 1 with parts removed for clarity, the cannula being shown in a contracted condition;

Fig. 3 is a schematic end view showing the cannula of Fig. 1 in the expanded position;

Fig. 4 is a rollout view of a part of the cannula of Fig. 1;

Fig. 5 is a schematic sectional view of the cannula of Fig. 1 during a surgical procedure.

Fig. 6 is an exploded perspective view of an apparatus constructed in accordance with one embodiment of the present invention;

Fig. 7 is a schematic top view of the apparatus of Fig. 6;

Fig. 8 is a schematic sectional view taken along line 8-8 in Fig. 7;

Fig. 9 is a schematic sectional view taken along line 9-9 in Fig. 7;

Fig. 10 is a schematic view partially in section of part of the apparatus of Fig. 6;

Fig. 11 is a schematic perspective view of a portion of Fig. 10;

Fig. 12 is a schematic sectional view taken along line 12-12 in Fig. 9;

Fig. 13 is a schematic sectional view taken along line 13-13 in Fig. 9;

Fig. 14 is a schematic detail view of part of the apparatus in Fig. 13;

Fig. 15 is an exploded schematic view of part of the apparatus of Fig. 6;

Fig. 16 is a schematic view taken along line 16-16 in Fig. 15;

Fig. 17 is a schematic view showing the parts of Fig. 15 with an associated mechanical arm; and

Fig. 18 is a schematic sectional view similar to Fig. 9 showing another feature of the apparatus of Fig. 6.

Fig. 19 is an exploded perspective view of an apparatus constructed in accordance with another embodiment of the present invention;

Fig. 20 is a schematic top view of the apparatus of Fig. 19;

Fig. 21 is a schematic sectional view taken along line 21-21 in Fig. 20;

Fig. 22 is a schematic sectional view taken along line 22-22 in Fig. 20;

Fig. 23 is a schematic view partially in section of part of the apparatus of Fig. 19;

Fig. 24 is a schematic perspective view of a portion of Fig. 23;

Fig. 25 is a schematic sectional view taken along line 25-25 in Fig. 22;

Fig. 26 is a schematic sectional view taken along line 26-26 in Fig. 22;

Fig. 27 is a schematic detail view of part of the apparatus in Fig. 26;

Fig. 28 is a schematic sectional view similar to Fig. 22 showing features of the second embodiment of the present invention;

Fig. 29 is a schematic detail view of part of the apparatus of Fig. 28;

Fig. 30 is a schematic sectional view similar to Fig. 22 showing features of the second embodiment of the present invention;

Fig. 31 is an exploded perspective view similar to Fig. 19 showing features of the second embodiment of the present invention;

Fig. 32 is a schematic detail view of a part that could be used in the apparatus of Fig. 31;

Fig. 33 is a schematic detail view of part of the apparatus of Fig. 28;

Fig. 34 is schematic detail view of another part that could be used in the apparatus of Fig. 31; and

Fig. 35 is a schematic sectional view of the cannula of Fig. 1 and the apparatus of Fig. 31 during a surgical procedure.

Description of Example Embodiments

As representative of one embodiment of the present invention, the Figures illustrate an apparatus 10 (Fig. 6) for use in percutaneous surgery (Fig. 35) in

association with a cannula 11 (Fig. 2). The apparatus 10 includes a base 118, a part 140 adapted to be fixed to a camera head 200, a screw mechanism 160 connected between the base and the part, and a cannula clamp 180 connected with the base. The cannula clamp 180 may form a second part of the apparatus 10 that is adapted to be fixed to the cannula 11. The part 140 and camera head 200 are rotatable relative to the cannula clamp 180.

The camera head 200 consists of a main body portion 201 and a light port 202. An endoscope (Figs. 5 and 35) may be threaded onto the main body portion 201 and secured to the main body portion. Part of the endoscope may extend through the cannula 10 into the patient's body 130.

A conventional cannula is a cylindrical metal or plastic tube with a channel extending completely through the cannula. The channel has a central axis. The cannula is inserted through an incision into a body of a patient during surgery.

Figs. 1-5 illustrate one suitable cannula 11 constructed for use with an apparatus 10 in accordance with this embodiment of the present invention. The cannula 11 is similar to a cannula shown in U.S. Patent

No. 6,187,000, incorporated herein entirely by reference. U.S. Patent Application Serial No. 09/772,605, filed January 30, 2001 in the names of Thomas Davison et al., incorporated herein entirely by reference, discloses other cannula structures that may be used with the apparatus 10. A specific cannula structure is not envisioned as part of the present invention. The cannula 11 will be described below by way of example of a cannula usable with this embodiment of the present invention.

The cannula 11 (Figs. 1-5) is a tubular structure 12 centered on a central axis 14. The tubular structure 12 defines a passage 16 through the cannula 11. Surgical instruments and an endoscope are inserted into a patient's body through the passage 16 during surgery.

The tubular structure 12 comprises a first tubular portion 20 and a second tubular portion 40 attached to the first tubular portion. The first tubular portion 20 is preferably made of a length of stainless steel tubing, but could alternatively be made of another suitable material. The first tubular portion 20 has a proximal end 22 and a distal end 24. Parallel cylindrical inner and outer surfaces 26

and 28, respectively, extend between the ends 22, 24 of the first tubular portion 20. The inner surface 26 defines a first passage portion 30 of the passage 16 through the cannula 11. The first passage portion 30 has a diameter D1 that is preferably in the range from 10 mm to 30 mm.

The second tubular portion 40 of the tubular structure 12 is attached to the distal end 24 of the first tubular portion 20. The second tubular portion 40 is preferably made from stainless steel, but could alternatively be made from another suitable material.

As best seen in the rollout view of Fig. 4, the second tubular portion 40 comprises an arcuate segment 42 of sheet stock. The arcuate segment 42 includes first and second arcuate edges 44 and 46, respectively, and first and second planar edges 48 and 50, respectively. The first and second planar edges 48 and 50 are rolled in an overlapping manner to form the tubular configuration of the second tubular portion 40.

When the second tubular portion 40 has been rolled into its tubular configuration, the first and second arcuate edges 44 and 46 define oppositely disposed

first and second ends 60 and 62 (Figs. 1 and 2), respectively, of the second tubular portion. The first and second ends 60 and 62 are connected by a central portion 64. The first end 60 of the second tubular portion 40 is attached to the distal end 24 of the first tubular portion 20 by a single fastener, such as a rivet 66. The rivet 66 extends through two aligned apertures 68 (Fig. 4) at the first end 60 of the second tubular portion 40. The first end 60 of the second tubular portion 40 is pivotable about the rivet 66.

The second tubular portion 40 includes parallel inner and outer surfaces 70 and 72 (Figs. 1 and 2), respectively, extending between the first and second ends 60 and 62. The inner surface 70 defines a second passage portion 74 of the passage 16 through the cannula 11 that extends as a continuation of the first passage portion 30 in the first tubular portion 20.

An arcuate slot 80 is formed in the second tubular portion 40 and extends between the inner and outer surfaces 70 and 72 of the second tubular portion. The arcuate slot 80 extends along a curvilinear path in the central portion 64 of the second tubular portion 40 toward the second end 60 of the second tubular portion. The arcuate slot 80 has a first terminal end 82 located

in the central portion 64 of the second tubular portion 40. A second terminal end 84 of the arcuate slot 80 is located adjacent the intersection of the second arcuate edge 46 and the first planar edge 48 of the arcuate segment 42.

A guide pin 90 is attached to the inner surface 70 of the second tubular portion 40 adjacent the intersection of the second arcuate edge 46 and the second planar edge 50. In the tubular configuration of the second tubular portion 40, the guide pin 90 is located in the arcuate slot 80 and is movable along the curvilinear path of the arcuate slot. A washer 92 is secured to an inner end of the guide pin 90 to retain the guide pin in the arcuate slot 80.

The second tubular portion 40 of the tubular structure 12 is expandable from a contracted condition shown in Fig. 2 to an expanded condition shown in Fig. 1. In the contracted condition, the guide pin 90 is located in the first terminal end 82 of the arcuate slot 80 in the second tubular portion 40 and the second passage portion 74 defined by the second tubular portion is cylindrical in shape. The second passage 74 has a generally constant diameter D2 (Figs. 2 and 3) that is approximately equal to the diameter D1 of the

first tubular portion 20. Thus, the cross-sectional area of the second passage portion 74 at the second end 62 of the second tubular portion 40, which is a function of the diameter D2, is approximately the same as the cross-sectional area at the first end 60 of the second tubular portion and is approximately the same as the cross-sectional area of the first passage portion 30 in the first tubular portion 20.

In the expanded condition, the guide pin 90 is located in the second terminal end 84 of the arcuate slot 80 in the second tubular portion 40 and the second tubular portion has a frustoconical configuration. At the second end 62 of the second tubular portion 40, the second passage portion 74 has a diameter D3 (Fig. 3) that is larger then the diameter D2 of the second passage portion at the first end 60. Preferably, the diameter D3 of the second passage portion 74 at the second end 62 of the second tubular portion is 40% to 80% greater than the diameter D1 of the second passage portion at the first end 60.

Thus, in the expanded condition, the cross-sectional area of the second passage portion 74 at the second end 62 of the second tubular portion 40, which is a function of the diameter D3, is 16% to 64%

greater than the cross-sectional area of the second passage portion at the first end 60 of the second tubular portion. In the expanded condition, the cross-sectional area of the second passage portion 74 at the second end 62 of the second tubular portion 40 may be large enough to overlie a major portion of at least two adjacent vertebrae of a patient.

The cannula 11 includes an outer layer 31 (Fig. 1) for maintaining the second tubular portion 40 of the cannula 11 in the contracted condition. It is contemplated that other suitable means for maintaining the second tubular portion 40 in the contracted condition could be employed. The outer layer 31 comprises a section of plastic tubing 32 which is heat shrunk over both the first and second tubular portions 20, 40 to hold the second tubular portion in the contracted condition.

In addition, a loop of polyester string 34 for tearing the heat shrunk tubing 32 is wrapped around the heat shrunk tubing so that it extends both underneath and on top of the tubing. An outer end 36 of the string 34 extends beyond the tubing 32.

Fig. 1 shows an actuatable device 35 for expanding the second tubular portion 40 from the contracted

condition to the expanded condition. The actuatable device 35 comprises a manually operated expansion tool 37. The expansion tool 37 resembles a common pair of scissors and has a pair of legs 33 pivotally connected to one another. The expansion tool 37 includes a frustoconical end section 38 formed by a pair of frustoconical halves 39. Each of the frustoconical halves 39 extends from a respective one of the legs 33 of the expansion tool 37. It is contemplated that other suitable means for expanding the second tubular portion 40 toward the expanded condition could be employed, such as an inflatable balloon (not shown).

During an endoscopic surgical procedure, the cannula 11 is inserted into the body of a patient in the contracted condition. The outer end 36 of the string 34 is then manually pulled on by the surgeon. Pulling on the string 34 tears the heat shrunk tubing 32 most of the way along the heat shrunk tubing, which frees the second tubular portion 40 for expansion. The heat shrunk tubing 32, in its torn condition, may remain attached to the first tubular portion 20.

Next, the expansion tool 37 is inserted into the passage 16 in the cannula 11 until the frustoconical end section 33 is located at the second end 62 of the second tubular portion 40. The legs 33 of the expansion tool 37 are manually separated, causing the frustoconical halves 39 to separate also. As the halves 39 separate, a radially outward directed force is exerted on the inner surface 70 of the second tubular portion 40 by the halves 39, causing the second tubular portion to expand toward the expanded condition. Under the force of the expanding expansion tool 37, the guide pin 90 slides from the first terminal end 82 of the arcuate slot 80 to the second terminal end 84 of the arcuate slot to permit the expansion of the second tubular portion 40. The expansion tool 37 can be rotated about the central axis 14 to ensure that the second tubular portion 40 of the cannula 11 is completely expanded to the expanded condition. The expansion tool 37 is then collapsed and removed so that one or more surgical instruments (indicated schematically at 21 in Fig. 5) and a viewing element (indicated schematically as part of the camera head 200 in Figs. 5 and 35) can be received through the cannula 11 and inserted vertically into a patient's

body 130. The cannula 11 may be angularly and/or laterally adjusted relative to the patient's body 130. Fig. 5 illustrates the cannula 11 positioned at about a 90° angle relative to the skin of the body 130. Fig. 35 illustrates the cannula 11 positioned at about a 75° angle relative to the skin of the body 130. The expanded second tubular portion 40 of the cannula 11 provides a large working area for the surgeon inside the body 130.

The expanded tubular portion 40 can dilate and locally retract and separate spinalis muscle and soft tissues from the vertebrae thereby creating an endoscopic operating field at the surgical site. This endoscopic operating field within the spinal muscles differs from arthroscopic, laparoscopic, or cystoscopic working spaces in that there is no physiologic space or defined tissue plane that is insufflated with air or distended with fluid.

As viewed in Fig. 6, the apparatus 10 of this embodiment of the present invention may be associated with the cannula 11 of Figs. 1-5. The apparatus 10 includes the base 118. The base 118 includes a base portion 120 and a guide portion 128. The base

portion 120 is secured to the guide portion 128 by conventional threaded fasteners 159 (Fig. 13).

The base portion 120 comprises a first generally cylindrical platform, or first disk 124, and a second generally cylindrical understructure, or second disk 125. The first disk 124 is a platform that has an upper partially circular surface area 124a. The first disk 124 is of uniform thickness and its upper circular surface area 124a is planar (flat). The first disk 124 has a first circular perimeter 121, and the second disk 125 has a second smaller circular perimeter 122. A central, circular aperture 126 in the central area of the first and second disks 124, 125 extends through the disks. The first and second perimeters 121, 122 have a center 123 located at the center of the central aperture 126.

A cylindrical sleeve part 800 is secured to the cannula clamp 180 by conventional fasteners 290 (Fig. 9) and is located in the central aperture 126. The proximal end 22 of the cannula 11 can be easily inserted into, and removed from, the sleeve part 800. When the cannula 11 is located in the sleeve part 800, an axis of the sleeve part extends through the center of the central aperture 126 and the axis of the cannula

also extends through the center of the central aperture 126. Thus, the cannula 11 and the sleeve part 800 are concentric about the central axis 14.

As viewed in Fig. 8, the guide portion 128 of the base 118 includes a horizontal base part 280, a first upright member 281 extending upward from the base part, and a second upright member 282 extending upward from the base part. The upright members 281, 282 have respective lower portions 283, 284 extending upward and parallel to each other. The upright members 281, 282 further have respective upper portions 285, 286 extending upward from the lower portions 283, 284 and toward each other. Each upper portion 285, 286 has a respective vertical, linear track 287, 288 for slidingly receiving the part 140.

The base part 280 has a right-hand threaded bore 289 extending vertically from a lower surface 291 of the base part to an upper surface 292 of the base part. The upper surface 292 is located between the upright members 281, 282.

One of the upright members 281, 282 may have a horizontal threaded bore 294 for receiving a stop member 295. The stop member 295 has a partially threaded shaft with a non-threaded end that extends

horizontally through the upright member 281 or 282 into the area between the upright members 281, 282. The non-threaded end acts as a vertical limit stop for a part 630 of the screw mechanism 160.

As viewed in Fig. 6, the part 140 connects to the camera head 200. Part of the camera head 200 (Fig. 5) may extend through the channel 12 of the cannula 11 into the patient's body 130.

The part 140 comprises a generally rectangular body having a passage through which the camera head 200 extends. As viewed in Figs. 10 and 11, the part 140 includes six planar sides. These sides define first and second opposite, generally rectangular guide surfaces 451, 452 (Fig. 8), first and second opposite, generally rectangular engagement surfaces 461, 462 (Fig. 10), and first and second opposite, generally square lateral surfaces 471, 472.

The passage in the part 140, through which the camera head 200 extends, includes a first generally rectangular passage portion 441 and a second passage portion 442 sized for receiving the main body portion 201. A transition point 443 in the passage is located where the first passage portion 441 and the second passage portion 442 come together.

The first passage portion 441 extends horizontally from the first lateral surface 471 through about 2/3 of the distance between the lateral surfaces 471, 472 to the transition point 443. The second passage portion 442 includes a cylindrical passage portion that communicates with the first passage portion 441 and extends horizontally from the transition point 443 to the second lateral surface 472. The second passage portion 442 forms a circular opening 445 in the lateral surface 472. The perimeter of the circular opening 445 forms a surface for tightly engaging the main body portion 201 of the camera head 200.

The part 140 further includes a slot 455 for receiving the light port 202 of the camera head 200 and, an electric cord of the endoscope (not shown). The slot 455 extends vertically upward from the first and second passage portions 441, 442 that receive the main body portion 201. The slot 455 intersects the first engagement surface 461. The slot 455 extends horizontally from the first lateral surface 471 to the second lateral surface 472 and intersects the lateral surfaces. The portion of the slot 455 that is adjacent the first passage portion 441 is defined by curved edges 457 for abuttingly engaging the light port 202.

The slot 455 further includes a cylindrical portion 446 (Fig. 8). The cylindrical portion 446 has a surface that is sized to tightly engage the light port 202. The cylindrical portion 446 intersects the second lateral surface 472 and forms a circular opening in the second lateral surface. The cylindrical portion 446 has a smaller diameter than the first circular opening 445. The curved edges 457 of the slot 455 extend a part of the circle defined by the cylindrical portion 446 from the transition point 443 to the first lateral surface 471.

The second engagement surface 462 of the part 140 includes a generally rectangular slot 465 for receiving a part 623 (Fig. 10) of the screw mechanism 160. The slot 465 extends vertically upward from the second engagement surface 462 to the first passage portion 441. The slot 465 may have rounded ends, as viewed in Fig. 11.

One of the guide surfaces 451, 452 may have one or two threaded bores 458 extending horizontally from the guide surfaces 451, 452 to the first passage portion 441. These bores 458 may have set screws 459, such as conventional threaded fasteners, or ball plungers 400 (discussed below), threaded into them for

engaging and releasably securing the camera head 200 to the part 140.

Each lateral surface 471, 472 has a threaded bore 478 penetrating from the guide surface 471, 472 to the slot 465. These bores 478 may have set screws or ball plungers 400 threaded into them for releasably securing the part 623 of the screw mechanism 160 in the slot 465. A ball plunger 400 is illustrated in Fig. 10 releasably securing the part 623 in the slot 465.

As viewed in Fig. 14, a ball plunger 400 is shown securing the base 118 to the sleeve part 800. Such a ball plunger 400 could optionally be replaced by a set screw 459. Each ball plunger 400, including those in the part 140 and base 118, has an externally threaded tubular body 402 with a cylindrical cavity 404 located therein. The cavity 404 houses a projection 406 and a coiled spring 408. The spring 408 urges each projection 406 against a lip portion 409 of the body 402. The lip portion 409 is located at one end of the cavity 404. Each ball plunger 400 has projections 406 with spherical detent members 420 and shoulder portions 422.

Each ball plunger 400 further includes a head portion 430 with a slot 432 for receiving a tool, such

as a screwdriver. Each ball plunger 400 may be threadedly adjusted within a threaded bore to alter the distance that the spherical detent member 420 projects away from the threaded bore. This distance, along with the stiffness of each spring 408, will determine a holding force applied by the ball plunger 400.

As viewed in Fig. 8, the screw mechanism 160 provides for vertical adjustment of the part 140 relative to the base 118 parallel to the central axis 14 of the cannula 11. The screw mechanism 160 includes a first large diameter spindle 610, a second small diameter spindle 620, and a wheel member, or thumb wheel 630. The thumb wheel 630 and the first spindle 610 rotate about a secondary axis 614 parallel to the central axis 14 and spaced apart from the central axis. The first spindle 610 and the thumb wheel 630 may be made of plastic and integrally molded together as one piece. The right-hand threaded bore 289 of the base part 280, the first spindle 610, the second spindle 620, and the thumb wheel 630 are all symmetric about the secondary axis 614.

The first spindle 610 has right-hand male threads 611 for engaging the female threads of the right-hand threaded bore 289 of the base part 280. As

the first spindle 610 is rotated, due to manual force applied to the thumb wheel 630, about the secondary axis 614, the first spindle 610 moves axially along the secondary axis 614 vertically into, or out of, the right-hand threaded bore depending upon the direction of rotation. The second spindle 620 has opposite left hand male threads 621 for engaging female threads of a left-hand threaded bore 612 centered on the secondary axis 614 and located in the first spindle 610.

The second spindle 620 further has the part 623 which is rectangular, planar end portion 623 inserted into the slot 465 of the part 140. The part 623 is a generally rectangular, planar end portion of the second spindle 620. Set screws or preferably ball plungers 400, threaded into the bores 478 in the part 140, engage planar surfaces of the end portion 623 and secure (along with the tracks 287, 288 of the base 118) the part 140 against rotational movement relative to the second spindle 620. The ball plungers 400 or set screws also releasably secure the part 140 against axial movement relative to the end portion 623 of the second spindle 620.

The end portion 623 of the second spindle 620 may have hemispherical recesses 625 for receiving the end

of the set screws or the spherical detent members 420 of the ball plungers 400 (Fig. 10). The second spindle 620 may be removed from the slot 465 of the part 140 by disengaging the ends of the set screws from the hemispherical recesses 625 or by overcoming the bias of the spherical detent members 420 in the hemispherical recesses.

The thumb wheel 630 has a knurled perimeter 631 to facilitate manual rotation of the thumb wheel about the secondary axis 614. When rotation is imparted to the thumb wheel 630, the threaded engagement between the right-hand female threads of the right-hand threaded bore 289 of the base 118 and the right-hand male threads 611 of the first spindle 610 either raises or lowers the first spindle vertically relative to the base depending upon the direction of rotation. Simultaneously, the threaded engagement between the left-hand female threads of the left-hand threaded bore 612 of the first spindle 610 and the left-hand male threads 621 of the second spindle 620 either raises or lowers (depending on the direction of rotation) the second spindle vertically relative to the first spindle. This opposite hand thread arrangement results in an amplified movement of the second

spindle 620 for each single rotation of the thumb wheel 630 because the two sets of threads work in concert to axially move the first spindle 610 and second spindle in the same direction, instead of acting against each other as would occur if the threads were both left-hand or both right-hand.

The part 140, being secured to the end portion 623 of the second spindle 620, is moved linearly parallel to the axis 14 of the cannula 11 (or vertically) upon rotation of the thumb wheel 630. The part 140 slides along the linear tracks 287, 288 of the guide portion 128 with the stop member 295 providing an upper limit for the position of the part 140. As the part 140 moves, the tracks 287, 288 may engage the lateral surfaces 271, 272 of the part 140 and block rotation of the part. Also, the tracks 287, 288 guide the vertical movement of the part 140. Upon vertical movement of the part 140, the camera head 200 is vertically adjusted since it is secured in the passage in the part 140, as described above.

As viewed in Fig. 12, the cannula clamp 180 includes two gripper arms 182, 184 that are deflected toward each other to clamp against the outer surface 28 of the cannula 11, a gripper actuating lever 976 for

deflecting the gripper arms 182, 184 into gripping engagement with the outer surface 28 of the cannula, and an adjustment mechanism 186 for changing the relative position of the gripper arms 182, 184 from which the arms are moved by the actuating lever to enable the arms to clamp different diameter cannulas. The gripper actuating lever 976 also releases the gripper arms 182, 184 from gripping engagement with the outer surface 28 of the cannula 11. When released, the gripper arms will spring away from the outer surface 28 of the cannula 11. The two gripper arms 182, 184 may grip the plastic tubing 32 depending on the position of the plastic tubing on the first tubular portion 20 of the cannula 11 (as described above). References in this application to gripping the outer surface of the cannula are meant to also cover the gripper arms engaging the plastic tubing.

The adjustment mechanism 186 includes a threaded stud 977 with a longitudinal axis, an adjustment knob 989 with a female threaded bore, and a lock pin 990. The threaded stud 977 has a head 979, a threaded shaft 980 for screwing into, and through, the threaded bore of the adjustment knob 989, and an oblong, or flat end 981 which extends through an oblong

bore 183 in the gripper arm 182. Alternative structures for the adjustment mechanism 186 are envisioned by the present invention.

During assembly, the flat end 981 of the threaded stud 977 is threaded through the bore of the adjustment knob 989 and inserted horizontally through a circular bore (not shown) in the gripper arm 184 that is larger in diameter than the diameter of the threaded stud 977 and through the oblong bore 183 in the gripper arm 182. The flat end 981 of the threaded stud 977 is then horizontally inserted into a longitudinal slot 975 in the lever 976. The threaded stud 977 is secured against rotation relative to gripper arms 182, 184 by engaging surfaces of the gripper arms 182, 184 defining bore 183 on gripper arm 182 and similar surfaces on arm 184 defining the oblong bore in arm 184. The lock pin 990 is then inserted vertically through a bore (not shown) in the lever 976 and through a bore (not shown) in the flat end 981 of the threaded stud 977 thereby securing the adjustment mechanism 186 together. The lever 976 is free to rotate about the lock pin 990.

The adjustment knob 989 may be axially positioned along the threaded stud 977 by rotation of the adjustment knob about the secured threaded stud. By

changing the axial position of the adjustment knob 989, the gripper arm 184 moves relative to the threaded stud 977 and the distance between the gripper arms 182, 184 changes and the relative positions of the gripper arms change. Rotation of the adjustment knob 989 in one direction may move the gripper arms 182, 184 closer together and rotation in the opposite direction may allow the arms to spring apart.

A camming surface 978 on the lever 976, adjacent the gripper arm 182, moves the arms 182, 184 a predetermined distance together to grip the outer surface 28 of the cannula 11 as the lever 976 is rotated clockwise about the lock pin 990 to the position shown in Fig. 12. Counterclockwise rotation of the lever 976 about the lock pin 990, from the position shown in Fig. 12, allows the gripper arms 182, 184 to spring (move) apart and releases the outer surface 28 of the cannula 11 from the cannula clamp 180.

The gripper arms 182, 184 have a normal position from which the gripper arms may be moved a predetermined distance by the actuating lever 976 to grip a cannula 11 having a first diameter. Rotation of the adjustment knob 989 in one direction relative to

the stud 977 causes arms 182, 184 to resiliently deflect toward each other and take new positions. The gripper arms 182, 184 may be moved from these new positions a predetermined distance by the actuating lever 976 to grip a cannula 11 having a second diameter smaller than the first diameter. Rotation of the adjustment knob 989 in a second direction opposite the first direction allows the gripper arms 182, 184 to spring back toward their normal positions. It should be apparent that the adjustment knob 989 enables the cannula clamp 180 to securely grip cannulas of different diameters.

When the cannula clamp 180 is released from the cannula 11, the base 118 and parts (i.e., the endoscope) attached to the base may move along the central axis 14 of the cannula 11 relative to the cannula. After the apparatus 10 is initially aligned with the cannula 11, the camera head 200 may be positioned on the apparatus 10 and axially adjusted along the central axis 14 in this manner. After the cannula clamp 180 grips the outer surface 28 of the cannula 11, the screw mechanism 160 provides for vertical adjustment of the camera head 200 relative to the cannula.

As viewed in Fig. 6, the cylindrical sleeve part 800, which is secured to the cannula clamp 180, may be inserted into the central aperture 126 of the base 118. The sleeve part 800 has a passage extending through the sleeve part, which passage receives the cannula 11. As viewed in Fig. 9, the upper edges of the sleeve part 800 and the proximal end 22 of the cannula 11 are typically assembled flush with the upper surface area 124a of the first disk 124. The sleeve part 800 is centered about the central axis 14 and includes a cylindrical outer surface 810, a horizontal groove 814 which extends around the cylindrical outer surface, and a horizontal array of spaced apart recesses 816 in the cylindrical outer surface. The recesses 816 lie in a horizontal plane parallel to, and axially offset from, a plane defined by the groove 814, both planes being perpendicular to the central axis 14.

As viewed in Fig. 13, the sleeve part 800 is axially secured in the central aperture 126 of the base 118 by set screws 459 or, more preferably, by ball plungers 400 extending radially into the central aperture and engaging the groove 814. The sleeve part 800 is rotationally (and axially) secured in the central aperture 126 of the base 118 by the set

screws 459 or the ball plungers 400 extending radially into the central aperture and being received in the recesses 816. The set screws 459 or ball plungers 400 are threaded radially inward through threaded radial bores 127 that penetrate radially inward from the second perimeter 122 of the base 118 to the central aperture 126. Four radial bores 127a are axially aligned with the groove 814 and are located at 90° increments about the central aperture 126. Correspondingly, four additional radial bores 127b are axially aligned with the recesses 816 at 90° increments, but angularly offset 45° from the four bores 127a.

If set screws 459 are used, the distal ends of the set screws form detents that engage the groove 814 and support the sleeve part 800 in the central aperture 126, but allow the base 118 and sleeve part to rotate relatively about the central axis 14. The recesses 816 of the sleeve part 800 and the detents formed by set screws 459 form an indexing mechanism that secures the sleeve part at selected angular increments about the central axis 14 relative to the base 118. Thirty-six (36) recesses 816 are spaced about the cylindrical outer surface 810 at 10°

increments. Thus, when the set screws 459 are threadedly disengaged from the recesses 816, the base 118 may be rotated about the central axis 14 relative to the fixed cannula clamp 180, while the base 118 is axially secured by the set screws 459 engaging the groove 814. After 10° of rotation (or some multiple of 10°), the set screws 459 may be threaded inward for reengaging the recesses 816 and rotationally securing the base 118 to the cannula clamp 180. An access bore 129 is located in the base part 280 for providing access to the bore 127b that is disposed against the guide portion 128 of the base 118.

If ball plungers 400 are used, which is preferable, the spherical detent members 420 form detents that engage in the groove 814 and support the sleeve part 800 in the central aperture 126, but allow the base 118 and the sleeve part to rotate about the central axis 14. The recesses 816 of the sleeve part 800 and the detents formed by ball plungers 400 form an indexing mechanism that secures the sleeve part at selected angular increments about the central axis 14 relative to the base 118. Thirty-six (36) recesses 816 are spaced about the cylindrical outer surface 810 at 10° increments. Thus, with minimal

manual force to overcome the biasing force of the ball plungers 400, the base 118 may be rotated about the central axis 14 relative to the fixed cannula clamp 180, thereby disengaging the biased spherical detent members 420 from the recesses 816. The base 118 will remain axially secured by the ball plungers 400 engaging the groove 814. The spherical detent members 420 reengage the recesses after 10° of rotation.

However, if rotation of the base 118 more than 10° is desired, the manual force applied to the base can continue to rotate the base. As should be apparent, the base 118 and the camera head 200 may rotate about 270° about the central axis 14 of the cannula 11 and be adjustably fixed at 10° increments. This enables the surgeon to view different parts of the surgical site, as desired.

The sleeve part 800 of the cannula clamp 180 can be easily removed from the central aperture 126 for cleaning, maintenance, etc. of the parts by disengaging the set screws 459 from the groove 814 and the recesses 816, or by overcoming the biasing force applied by the ball plungers 400 to the sleeve part. As viewed in Fig. 18, the sleeve part 800 may have an

annular retaining lip 813 for engaging the proximal end 22 of the cannula 11. The retaining lip 813 extends radially inward and provides an upper limit stop that prevents the cannula 11 from extending upward (axially) from the central aperture 126. The upper edge of the retaining lip 813 is typically mounted flush with the upper surface area 124a of the first disk 124.

As viewed in Figs. 15-17, the cannula clamp 180 is a part of the support arm 300 for attaching the apparatus 10 to a mechanical robotic arm 301. The support arm 300 includes an arm portion 302 which may be formed integrally with the gripper arms 182, 184. As viewed in Fig. 9, the arm portion 302 extends upwardly away from the gripper arms 182, 184 in order to minimize the possibility of contact with the patient during surgery.

The support arm 300 also includes an arm portion 303. The arm portion 303 has an attaching structure 304, including a groove 305, which snaps into a socket in the mechanical arm 301. Detents of any suitable type and designated 306 in the mechanical arm 301, hold the arm portion 303 in position in the socket in the mechanical arm 301. The detents 306 may

be controlled by external actuation levers (not shown) on the mechanical arm 301 for manually releasing the arm portion 303 from the mechanical arm 301.

The arm portions 302 and 303 are pivotally connected to each other by a fastener 310. The fastener 310 extends through an opening 311 in the arm portion 302 and threads into a threaded opening 312 in the arm portion 303. When the fastener 310 is released, the arm portions 302, 303 may pivot relative each other about a pivot axis 314. The pivot axis 314 is centered on the axis of the fastener 310 and the axis of the threaded opening 312. When the fastener 310 is tightly screwed into the threaded opening 312, the arm portions 302, 303 are secured together against pivoting movement. When the fastener 310 is released, the arm portions 303, 302 may pivot relative to each other about the axis 314.

The end of the arm portion 302, which is adjacent to the arm portion 303, has a convex surface 350, which is curved about the axis 314. The arm portion 303 has a concave surface 351, which is also curved about the axis 314. The surfaces 350, 351 move concentrically relative to each other when the arm portions 302, 303 pivot relatively about the axis 314.

The arm portion 303 has a set of teeth 320 which encircle the axis 314 and which project axially toward a set of teeth 321 on the arm portion 302. The teeth 321 project axially toward the teeth 320. The teeth 320 and the teeth 321 mesh with each other and provide a locking action so that the arm portions 302, 303 are positively locked against relative movement about the axis 314 when the fastener 310 is tightly screwed into the opening 312. The teeth 320, 321 define a lock which blocks relative rotation of the arm portions 302, 303 about the axis 314. When the fastener 310 is loosened, the arm portions 302, 303 may be rotated relative to each other about the axis 314, and thus, the arm portions 302, 303 may pivot relative to each other to adjust the position of the apparatus 10.

A cylindrical projection 325 is welded to the arm portion 303. Thus, the projection 325 and arm portion 303 are fixedly connected together. The projection 325 is centered on the axis 314 and contains a chamber 328.

As viewed in Fig. 17, the chamber 328 communicates with a fluid passage 329 in a male fluid connector 331. The male connector 331 attaches to a male connector 333

on the mechanical arm 301 by means of a flexible hose 392 so that the fluid passage 329 communicates with a fluid passage in the mechanical arm 301.

As viewed in Fig. 15, the chamber 328 is closed at its upper end by a cap 335. The cap 335 has an opening 336 centered on the axis 314. The opening 336 communicates with the chamber 328. A manually movable internal valve member 340 normally closes the opening and blocks the chamber 328 from communicating with the ambient air surrounding the support arm 300. The valve member 340 is connected to a stem 341, which is also centered on the axis 314. The stem 341 has a knob or button 343 on its end which may be manually depressed to move the stem 341 and valve member 340 downward into the chamber 328. When the stem 341 and valve member 340 are so moved, the chamber 328 is in communication with the ambient air surrounding the device due to the unblocking of the opening 336.

The mechanical arm 301 is a known device and is of the type generally disclosed in U.S. Patent No. 4,863,133, incorporated herein entirely by reference. The mechanical arm 301 is sold by Leonard Medical, Inc. 1464 Holcomb Road, Huntington Valley, PA, 19006. The mechanical arm 301 includes relatively

movable parts, which permit movement and adjustment of the apparatus 10 in a variety in planes, directions, and orientations. The mechanical arm 301 permits easy movement when a vacuum is not applied to the arm 301. When a vacuum is applied to the arm 301, relative movement of the parts of the arm 301 is resisted, and therefore adjustment of the apparatus 10 is difficult. Other structures can be used instead of the mechanical arm 301.

When the button 343 is depressed, the chamber 328 loses its vacuum and the pressure in the chamber 328 increases toward ambient pressure. The passage 329 communicates this pressure increase to the mechanical arm 301, and thus the parts of the mechanical arm 301 are free to move and allow for adjustment of the position of the apparatus 10 by the surgeon.

Accordingly, when the surgeon uses the apparatus 10, the support arm 300 is snapped into the socket of the mechanical arm 301 where it is held by the detent 306. The surgeon may then depress the button 343 and relatively move parts of the mechanical arm 301 as well as the apparatus 10 into the position where the surgeon desires the apparatus 10 to be. This position may be where the central aperture 126 of the

base 118 and the sleeve portion 800 are aligned with the proximal end 22 of the cannula 11 and the distal end 24 of the cannula 11 is located in an incision in the body of a patient. The camera head 200 may be mounted on the apparatus 10, and the surgeon may make adjustments prior to, and during, the surgical procedure as desired, as described above.

As viewed in Fig. 9, the fixed connection of the sleeve portion 800 to the support arm 300 may be made by one or more suitable metal fasteners 290, such as rivets or bolts. The sleeve portion 800 is axially offset from the gripper arms 182, 184 in order to allow the gripper arms to flex against the outer surface 28 of the cannula 11.

The entire apparatus 10 can be constructed from metal or any other suitable material having sufficient mechanical strength, flexibility, and durability. Certain parts may be made from materials permitting X-rays and other techniques for viewing the surgical site (i.e., radiopaque parts). Other parts may also be made from non-magnetic materials to reduce electromagnetic interference (i.e., electromagnetic insulating parts).

As representative of another embodiment of the present invention, the Figures illustrate an apparatus 1100 (Fig. 19) for use in percutaneous surgery in association with the cannula 11 (Fig. 2). The apparatus 1100 includes a base 1110, a structure comprising a first part 1200 and a second part 1300, a screw mechanism 1400 connected between the base and the second part, and a cannula clamp 1500 connected with the base. The first part 1200 is adapted to be fixed to the camera head 200. The second part 1300 is adapted to be secured to the first part. The cannula clamp 1500 is adapted to be clamped to the cannula 11. The base 1110, first part 1200, second part 1300, and camera head 200 are rotatable relative to the cannula clamp 1500.

The base 1110 of the apparatus 1100 includes a base portion 1120 and a guide portion 1300. The base portion 1120 is typically molded as one piece with the guide portion 1130. The base 1110 may be constructed as a suitable polymer such as polyetheretherketone (PEEK).

The base portion 1120 comprises a first generally cylindrical platform, or first disk 1121, and a second generally cylindrical understructure, or second

disk 1122 (Fig. 22). The first disk 1121 is a platform that has an upper partially circular surface area 1121'. The first disk 1121 is of uniform thickness and its upper circular surface 1121' is planar (flat). The first disk 1121 has a first circular perimeter 1123, and the second disk 1122 has a second, smaller circular perimeter 1124. A central, circular aperture 1125 in the central area of the first and second disks 1121, 1122 extends through the disks. The first and second perimeters 1123, 1124 have a center 1126 (Fig. 20) located at the center of the central aperture 1125.

A generally cylindrical sleeve part 1600 is secured to the cannula clamp 1500 by conventional fasteners 1599 (Fig. 22). The sleeve part 1600 is located in the central aperture 1125. The proximal end 22 of the cannula 11 can be easily inserted into, and removed from, the sleeve part 1600. When the cannula 11 is located in the sleeve part 1600, an axis of the sleeve part extends through the center 1126 of the central aperture 1125 and is coincident with the central axis 14 of the cannula. The axis of the sleeve part 1600 also extends through the center 1126 of the central aperture 1125. Thus, the cannula 11 and the

sleeve part 1600 are concentric about the central axis 14.

As viewed in Fig. 21, the guide portion 1130 of the base 1110 includes a horizontal base part 1132, a first upright member 1141 extending upward from the base part, and a second upright member 1142 extending upward from the base part. The upright members 1141, 1142 have respective lower portions 1151, 1152 extending upward and parallel to each other. The upright members 1141, 1142 further have respective upper portions 1161, 1162 extending upward from the lower portions 1151, 1152 and toward each other. Each upper portion 1161, 1162 has a respective vertical, linear track 1171, 1172 for slidingly receiving the second part 1300.

The base part 1132 of the guide portion 1130 has a right-hand threaded bore 1134 extending vertically from a lower surface 1136 of the base part to an upper surface 1138 of the base part. The upper surface 1138 is located between the upright members 1141, 1142.

As viewed in Fig. 20, one of the upright members 1141, 1142 may have a horizontal threaded bore 1145 for receiving a stop member 1147. The stop member 1147 has a partially threaded shaft with a

non-threaded end that extends horizontally through the upright member 1141 or 1142 into the area between the upright members 1141, 1142. The non-threaded end acts as a vertical limit stop for a part 1430 of the screw mechanism 1400.

As viewed in Fig. 19, the first part 1200 connects to the camera head 200. An endoscope (not shown) may be threaded into the main body portion 201 and secured to the main body portion. Part of the endoscope (Figs. 5 and 35) may thereby extend through the cannula 11 into the patient's body 130.

The first part 1200 comprises a generally U-shaped body having a passage through which the endoscope extends. As viewed in Figs. 21 and 24, the first part 1200 includes five planar surfaces and one cylindrically shaped bottom surface. These surfaces define first and second opposite, generally rectangular guide surfaces 1211, 1212 (Fig. 21), a generally rectangular first engagement surface 1221 (Fig. 23), a second cylindrically shaped engagement surface 1222 (Fig. 23), and first and second opposite, generally rectangular lateral surfaces 1231, 1232. The guide surfaces 1211, 1212 include rail members 1215, 1216 for slidably engaging the second part 1300.

As viewed in Fig. 23, the passage in the first part 1200, through which the camera head 200 extends, includes a first generally rectangular passage portion 1241 and a second passage portion 1242 sized for receiving and engaging the main body portion 201. A transition point 1243 in the passage is located where the first passage portion 1241 and the second passage portion 1242 come together.

The first passage portion 1241 extends horizontally from the first lateral surface 1231 through about 2/3 of the distance between the lateral surfaces 1231, 1232 to the transition point 1243. The second passage portion 1242 includes a cylindrical passage portion that communicates with the first passage portion 1241 and extends horizontally from the transition point 1243 to the second lateral surface 1232. The second passage portion 1242 forms a first circular opening 1245 in the lateral surface 1232. The perimeter of the first circular opening 1245 forms a surface for tightly engaging the main body portion 201 of the camera head 200.

The first part 1200 further includes a slot 1255 for receiving the light port 202 of the camera head 200 and an electric cord (not shown) of the endoscope. The

slot 1255 extends vertically upward from the first and second passage portions 1241, 1242 that receive the main body portion 201. The slot 1255 intersects the first engagement surface 1221. The slot 1255 extends horizontally from the first lateral surface 1231 to the second lateral surface 1232 and intersects the lateral surfaces. The portion of the slot 1255 that is adjacent the first passage portion 1241 is defined by curved edges 1257 for abuttingly engaging the curved outer surface of the light port 202.

The second lateral surface 1232 further includes a second circular opening 1259 (Fig. 24). The second circular opening 1259 is sized tightly engage the curved outer surface of the light port 202. The second circular opening 1259 has a smaller diameter than the first circular opening 1245. The curved edges 1257 of the slot 1255 extend a part of the circle defined by the second circular opening 1259 from the transition point 1243 to the first lateral surface 1231.

One of the guide surfaces 1211, 1212 may have one or two threaded bores 1217 extending horizontally from the guide surfaces to the first passage portion 1241. These bores 1217 may have set screws 1218, such as conventional threaded fasteners, or ball plungers 1700

(discussed below), threaded into them for engaging and releasably securing the camera head 200 to the first part 1200.

The second part 1300 comprises a generally U-shaped body having a passage for receiving the first part 1200. The second part 1300 includes five planar external sides and one substantially open end. These sides define first and second opposite, generally rectangular guide surfaces 1311, 1312, a generally rectangular bottom engagement surface 1321, and first and second opposite, planar U-shaped lateral surfaces 1331, 1332 (Fig. 23).

The engagement surface 1321 of the second part 1300 includes a generally rectangular slot 1323 for receiving a part 1423 (Fig. 23) of the screw mechanism 1400. The slot 1323 extends vertically upward from the engagement surface 1321 to the passage of the second part 1300.

Each lateral surface 1331, 1332 is intersected by a respective circular bore 1335, 1336 extending from each lateral surface to the slot 1323. The bores 1335, 1336 are coaxial. A cylindrical pin 1305 may be inserted into one of the bores 1335, through an opening in the part 1423 of the screw mechanism 1400 and into

the other bore 1336 in order to secure the second part 1300 to the part 1423 of the screw mechanism 1400. The outer diameter of the cylindrical pin 1305 may be slightly larger than the inner diameter of the cylindrical bores 1335, 1336 and/or the opening in the part of the screw mechanism 1400 so that a press fit engagement further secures the second part 1300 to the screw mechanism 1400.

The passage of the second part 1300 includes two parallel guide tracks 1315, 1316 for slidably receiving the rail members 1215, 1216 of the first part 1200. Once the camera head 200 is secured in the passage of the first part 1200, the camera head and first part may be slid vertically downward, through the open end of the second part 1300, into the passage of the second part along the guide tracks 1315, 1316 until the second engagement surface 1222 of the first part 1200 abuttingly engages the base of the passage of the second part 1300. The base of the passage of the second part 1300 may be curved for continuous engagement with the second engagement surface 1222 of the first part 1200 (Fig. 21). The camera head 200 and first part 1200 are both thereby secured to the second part 1300. The guide tracks 1315, 1316 of the second

part 1300 and the rail members 1215, 1216 of the first part 1200 maintain the camera head 200 and first part 1200 in a stable position relative to the second part as the second part is vertically adjusted along the guide tracks 1171, 1172 of the guide portion 1130.

One of the guide surfaces 1311, 1312 of the second part 1300 may have one or two threaded bores 1355 extending horizontally from the guide surfaces to the first passage of the second part. These bores 1355 may have set screws 1357, such as conventional threaded fasteners, or ball plungers 1700 (discussed below), threaded into them for engaging and fixedly securing the first part 1200 to the second part 1300. Corresponding bores 1355 may be aligned with the bores 1217 of the first part 1200 so that the set screws 1357 or ball plungers 1700 may extend through both the first and second parts 1200, 1300 (Fig. 21).

As viewed in Figs. 26 and 27, a ball plunger 1700 is shown securing the base 1110 to the sleeve part 1600. Such a ball plunger 1700 could optionally be replaced by a set screw 1357. Each ball plunger 1700, including those in the first part 1200, the second part 1300 and/or base 1110, has an externally threaded tubular body 1702 with a

cylindrical cavity 1704 located therein. The cavity 1704 houses a projection 1706 and a spring 1708. The spring 1708 may be of any suitable construction and urges each projection 1706 against a lip portion 1709 of the body 1702. The lip portion 1709 is located at one end of the cavity 1704. Each ball plunger 1700 has projections 1706 with spherical detent members 1720 and shoulder portions 1722.

Each ball plunger 1700 further includes a head portion 1730 with a slot 1732 for receiving a tool, such as a screwdriver. Each ball plunger 1700 may be threadedly adjusted within a threaded bore to alter the distance that the spherical detent member 1720 projects away from the associated threaded bore. This distance, along with the stiffness of each spring 1708, will determine a holding force applied by the ball plunger 1700.

As viewed in Fig. 21, the screw mechanism 1400 provides for vertical adjustment of the second part 1300 relative to the base 1110 parallel to the central axis 14 of the cannula 11. The screw mechanism 1400 includes a first large diameter spindle 1410, a second small diameter spindle 1420, and a thumb wheel 1430. The thumb wheel 1430 and the first

spindle 1410 rotate about a secondary axis 1404 parallel to the central axis 14 and spaced apart from the central axis. The first spindle 1410 and the thumb wheel 1430 may be made of plastic and integrally molded together as one piece. The right-hand threaded bore 1134 of the base part 1132, the first spindle 1410, the second spindle 1420, and the thumb wheel 1430 are all symmetric about the secondary axis 1404.

The first spindle 1410 has right-hand male threads 1411 for engaging the female threads of the right-hand threaded bore 1134 of the base part 1132. As the first spindle 1410 is rotated, due to manual force applied to the thumb wheel 1430, about the secondary axis 1404, the first spindle 1410 moves axially along the secondary axis vertically into, or out of, the right-hand threaded bore 1134 depending upon the direction of rotation. The second spindle 1420 has opposite left hand male threads 1421 for engaging female threads of a left-hand threaded bore 1415 centered on the secondary axis 1404 and located within the first spindle 1410.

The upper end of the second spindle 1420 has the part 1423 that is a rectangular, planar end portion

inserted into the slot 1323 of the second part 1300. Instead of the cylindrical pin 1305, set screws 1357 or preferably ball plungers 1700 threaded into the bores 1335, 1336 in the second part 1300, may alternatively engage planar surfaces of the end portion 1423 and secure (along with the tracks 1171, 1172 of the base 1110) the second part 1300 against rotational movement relative to the second spindle 1420. The cylindrical pin 1305, set screws 1357, or ball plungers 1700 releasably secure the second part 1300 against axial movement relative to the end portion 1423 of the second spindle 1420.

If set screws 1357 or ball plungers 1700 are used, the end portion 1423 of the second spindle 1420 may alternatively have hemispherical recesses (not shown) for receiving the end of the set screws or the spherical detent members 1720 of the ball plungers. The second spindle 1420 may be removed from the slot 1323 of the second part 1300 by removing the cylindrical pin 1305, by disengaging the ends of the set screws 1357 from the hemispherical recesses, or by overcoming the bias of the spherical detent members 1720 in the hemispherical recesses.

As viewed in Fig. 21, the stop member 1147 may alternatively be replaced by a stop structure, or limit structure 1450, located internal to the first spindle 1410. The limit structure includes a generally cylindrical shoulder portion 1452 extending radially outward from the lower end of the second spindle 1420 and a lip portion 1451 extending radially inward from the upper end of the first spindle 1410. As the second spindle 1420 is threaded upward relative to the first spindle 1410, it will reach a position where the shoulder portion 1452 will abuttingly engage the lip portion 1451 of the first spindle and thereby prevent the second spindle from becoming disengaged from the first spindle. The second spindle 1420 can not be raised past this position relative to the first spindle 1410.

The thumb wheel 1430 has a knurled perimeter 1431 to facilitate manual rotation of the thumb wheel about the secondary axis 1404. When rotation is imparted to the thumb wheel 1430, the threaded engagement between the right-hand female threads of the right-hand threaded bore 1134 of the base 1130 and the right-hand male threads 1411 of the first spindle 1410 either raises or lowers the first spindle vertically relative

to the base 1110 depending upon the direction of rotation. Simultaneously, the threaded engagement between the left-hand female threads of the left-hand threaded bore 1415 of the first spindle 1410 and the left-hand male threads 1421 of the second spindle 1420 either raises or lowers (depending on the direction of rotation) the second spindle vertically relative to the first spindle. This opposite hand thread arrangement results in an amplified movement of the second spindle 1420 for each single rotation of the thumb wheel 1430 because the two sets of threads work in concert to axially move the first spindle 1410 and second spindle in the same direction, instead of acting against each other as would occur if the threads were both left-hand or both right-hand.

The second part 1300, being secured to the end portion 1423 of the second spindle 1420, is moved linearly parallel to the axis 14 of the cannula 11 (or vertically) upon rotation of the thumb wheel 1430. The second part 1300 slides along the linear tracks 1171, 1172 of the guide portion 1130 with the stop member 1147 or limit structure 1450 providing an upper limit for the position of the second part 1300. As the second part 1300 moves, the tracks 1171, 1172 may

engage the lateral surfaces 1331, 1332 of the second part 1300 and block rotation of the second part about the secondary axis 1404. Further, the tracks 1171, 1172 guide the vertical movement of the second part 1300. Upon vertical movement of the second part 1300 relative to the base 1110, the camera head 200 (and first part 1200) are thereby vertically adjusted, since they are secured in the passage in the second part 1300, as described above.

As viewed in Fig. 25, the cannula clamp 1500 includes two gripper arms 1511, 1512 that are deflected toward each other to clamp against the outer surface 28 of the cannula 11, a gripper actuating lever 1520 for deflecting the gripper arms into gripping engagement with the outer surface of the cannula, and an adjustment mechanism 1530 for changing the relative position of the gripper arms from which the arms are moved by the actuating lever to enable the arms to clamp different diameter cannulas. The gripper actuating lever 1520 also releases the gripper arms 1511, 1512 from gripping engagement with the outer surface 28 of the cannula 11. When released, the gripper arms 1511, 1512 will spring away from the outer surface 28 of the cannula 11. The two gripper

arms 1511, 1512 may grip the plastic tubing 32 depending on the position of the plastic tubing on the first tubular portion 20 of the cannula 11 (as described above). References in this application to gripping the outer surface 28 of the cannula 11 are meant to also cover the gripper arms 1511, 1512 engaging the plastic tubing 32.

The adjustment mechanism 1530 includes a threaded stud 1532 with a longitudinal axis, an adjustment knob 1538 with a female threaded bore, and a lock pin 1542. The threaded stud 1532 has a head 1534, a threaded shaft 1536 for screwing into, and through, the threaded bore of the adjustment knob, and an oblong, or flat end 1537 which extends through an oblong bore 1515 in the gripper arm 1511. Alternative structures for the adjustment mechanism 1530 are envisioned by the present invention.

During assembly, the flat end 1537 of the threaded stud 1532 is threaded through the bore of the adjustment knob 1538 and inserted horizontally through a circular bore (not shown) in the gripper arm 1512 that is larger in diameter than the diameter of the threaded stud and through the oblong bore 1515 in the gripper arm 1511. The flat end 1537 of the threaded

stud 1532 is then horizontally (as viewed in Figs. 22 and 25) inserted into a longitudinal slot 1525 in the lever 1520. The threaded stud 1532 is secured against rotation relative to gripper arms 1511, 1512 by engaging surfaces of the gripper arm defining the oblong bore 1515 on gripper arm 1511. The lock pin 1542 is then inserted vertically through a bore (not shown) in the lever 1520 and through a bore (not shown) in the flat end 1537 of the threaded stud 1532 thereby securing the adjustment mechanism 1530 together. The lever 1520 is free to rotate about the lock pin 1542.

The adjustment knob 1538 may be axially positioned along the threaded stud 1532 by rotation of the adjustment knob about the secured threaded stud. By changing the axial position of the adjustment knob 1538, the gripper arm 1512 moves relative to the threaded stud 1532 and the distance between the gripper arms 1511, 1512 changes and the relative positions of the gripper arms change. Rotation of the adjustment knob 1538 in one direction may move the gripper arms 1511, 1512 closer together and rotation in the opposite direction may allow the arms to spring apart.

A camming surface 1522 on the lever 1520, adjacent the gripper arm 1511, moves the arms 1511, 1512 a predetermined distance together to grip the outer surface 28 of the cannula 11 as the lever is rotated clockwise about the lock pin 1542 to the position shown in Fig. 25. Counterclockwise rotation of the lever 1520 about the lock pin 1542, from the position shown in Fig. 25, allows the gripper arms 1511, 1512 to spring (move) apart and releases the outer surface 28 of the cannula 11 from the cannula clamp 1500.

The gripper arms 1511, 1512 have a normal position from which the gripper arms may be moved a predetermined distance by the actuating lever 1520 to grip a cannula having a first diameter. Rotation of the adjustment knob 1538 in one direction relative to the stud 1532 causes arms 1511, 1512 to resiliently deflect toward each other and take new positions. The gripper arms 1511, 1512 may be moved from these new positions a predetermined distance by the actuating lever 1520 to grip a cannula having a second diameter smaller than the first diameter. Rotation of the adjustment knob 1538 in a second direction opposite the first direction allows the gripper arms 1511, 1512 to spring back toward their normal positions. The

adjustment knob 1538 enables the cannula clamp 1500 to securely grip cannulas of different diameters.

When the cannula clamp 1500 is released from the cannula 11, the base 1110 and parts (i.e., the camera head 200, the endoscope, etc.) attached to the base may move axially along the central axis 14 of the cannula 11 relative to the cannula. After the apparatus 1100 is initially aligned with the cannula 11, the camera head 200 may be positioned on the apparatus 1100 and axially adjusted along the central axis 14 in this manner. When the cannula clamp 1500 is gripping the outer surface 28 of the cannula 11, the screw mechanism 1400 provides for vertical (axial) adjustment of the camera head 200 relative to the cannula.

As viewed in Fig. 19, the cylindrical sleeve part 1600, which is secured to the cannula clamp 1500, may be inserted into the central aperture 1125 of the base 1110. The sleeve part 1600 has a passage extending through the sleeve part, which passage receives the cannula 11. As viewed in Fig. 22, the upper edges of the sleeve part 1600 and the proximal end 22 of the cannula 11 are typically assembled flush with the upper surface area 1121' of the first

disk 1121. The sleeve part 1600 is centered about the central axis 14 and includes a cylindrical outer surface 1610, a horizontal groove 1620 that extends around the cylindrical outer surface, and a horizontal array of spaced apart recesses 1630 in the cylindrical outer surface. The recesses 1630 lie in a horizontal plane parallel to, and axially offset from, a plane defined by the groove 1620, both planes being perpendicular to the central axis 14.

As viewed in Fig. 26, the sleeve part 1600 is axially secured in the central aperture 1125 of the base 1110 by set screws 1357 or, more preferably, by ball plungers 1700 extending radially into the central aperture and engaging the groove 1620. The sleeve part 1600 is rotationally (and axially) secured in the central aperture 1125 of the base 1110 by the set screws 1357 or the ball plungers 1700 extending radially into the central aperture and being received in the recesses 1630. The set screws 1357 or ball plungers 1700 are threaded radially inward through threaded radial bores 1127 that penetrate radially inward from the second perimeter 1124 of the base 1110 to the central aperture 1125. Three radial bores 1127' are axially aligned with the groove 1620 and are

located at 1120° increments about the central aperture 1125. Five additional radial bores 1127'' are axially aligned with the recesses 1630, three at 120° increments about the central aperture 1125, but angularly offset 60° from the three bores 1127' and two at diametrically opposed locations and offset 30° from two of the three bores 1127".

If set screws 1357 are used, the distal ends of the set screws form detents that engage the groove 1620 and support the sleeve part 1600 in the central aperture 1125, but allow the base 1110 and sleeve part to rotate relatively to the base about the central axis 14. The recesses 1630 of the sleeve part 1600 and the detents formed by set screws 1357 form an indexing mechanism that secures the sleeve part at selected angular increments about the central axis 14 relative to the base 1110. Thirty-six (36) recesses 1630 are spaced about the cylindrical outer surface 1610 at 10° increments. Thus, when the set screws 1357 are threadedly disengaged from the recesses 1630, the base 1110 may be rotated about the central axis 14 relative to the cannula clamp 1500 and the cannula secured thereto, while the base 1110 is axially secured by the set screws 1357 engaging the groove 1620.

After 10° of rotation (or some multiple of 10°), the set screws 1357 may be threaded inward for reengaging the recesses 1630 and rotationally securing the base 1110 to the cannula clamp 1500 and the cannula 11. An access bore 1128 is located in the base part 1132 of the guide portion 1130 for providing access to the bore 1127' that is disposed within the guide portion 1130 of the base 1110.

If ball plungers 1700 are used, which is preferable, the spherical detent members 1720 form detents that engage the groove 1630 and support the sleeve part 1600 in the central aperture 1125, but allow the base 1110 and the sleeve part to rotate about the central axis 14. The recesses 1630 of the sleeve part 1600 and the detents formed by ball plungers 1700 form an indexing mechanism that secures the sleeve part at selected angular increments about the central axis 14 relative to the base 1110. Thirty-six (36) recesses 1630 are spaced about the cylindrical outer surface 1610 at 10° increments. Thus, with minimal manual force to overcome the biasing force of the ball plungers 1700, the base 1110 may be rotated about the central axis 14 relative to the cannula clamp 1500 and the cannula 11 secured thereto, thereby disengaging the

biased spherical detent members 1720 from the recesses 1630. The base 1110 will remain axially secured by the ball plungers 1700 engaging the groove 1620. The spherical detent members 1720 reengage the recesses after 10° of rotation. The ball plungers 1700 may be further secured in the bores 1127 of the base 1110 by adhesive being applied to the externally threaded tubular bodies 1702 near each head portion 1730.

However, if rotation of the base 1110 more than 10° is desired, the manual force applied to the base can continue to rotate the base relative to the cannula clamp 1500 and the cannula 11. As should be apparent, the base 1110 and the camera head 200 (and the attached endoscope) may rotate at least 300° about the central axis 14 of the cannula 11 and be adjustably fixed at 10° increments. This enables the surgeon to view different parts of the surgical site, as desired. The sleeve part 1600 of the cannula clamp 1500 can be easily removed from the central aperture 1125 for cleaning, maintenance, etc. of the parts by disengaging the set screws 1357 from the groove 1620 and the recesses 1630, or by overcoming the biasing force applied by the ball plungers 1700 to the sleeve part.

The cannula clamp 1500 may be part of the support arm 300 of Figs. 15-17 for attaching the apparatus 1100 to a mechanical robotic arm 301. The support arm 300 may include an arm portion 1902 which may be formed integrally with the gripper arms 1511, 1512. As viewed in Fig. 22, the arm portion 1902 extends upwardly away from the gripper arms 1511, 1512 in order to minimize the possibility of contact with the patient during surgery. The remaining part of the support arm 300 is similar to the support arm illustrated in Figs. 15-17.

Accordingly, when the surgeon uses the apparatus 1100, the support arm 300 is snapped into the socket of the mechanical arm 301 where it is held by the detent 306. The surgeon may then depress the button 343 and relatively move parts of the mechanical arm 301 as well as the apparatus 1100 into the position where the surgeon desires the apparatus to be. This position may be where the central aperture 1125 of the base 1110 and the sleeve portion 1600 are aligned with the proximal end 22 of the cannula 11 and the distal end 24 of the cannula is located in an incision in the body of a patient. The camera head 200 (and the endoscope) may be mounted on the apparatus 1100, and

the surgeon may make adjustments prior to, and during, the surgical procedure as desired, as described above.

As viewed in Fig. 22, the fixed connection of the sleeve portion 1600 to the support arm 300 may be made by the fasteners 1599. The sleeve part 1600 is axially offset from the gripper arms 1511, 1512 in order to allow the gripper arms to flex against the outer surface 28 of the cannula 11.

As viewed in Fig. 28, the sleeve part 1600 may have an annular retaining lip 1641 for engaging the proximal end 22 of the cannula 11. The retaining lip 1641 extends radially inward toward the axis 14 and provides an upper limit stop that prevents the cannula 11 from extending upward (axially) from the central aperture 1125. The upper edge of the retaining lip 1641 is mounted flush with the upper surface area 1121' of the first disk 1121.

As viewed in Figs. 28 and 29, the cannula 11 may be further axially secured within the sleeve part 1600 by a cannula retainer structure 2000 (along with the retaining lip 1641) located near the retaining lip at an inner surface 1611 of the sleeve part 1600. The retainer structure 2000 includes a first retention groove 2010 disposed on the inner surface 1611 of the

sleeve part 1600, a corresponding second retention groove 2020 disposed in the outer surface 28 of the proximal end 22 of the cannula 11, and a split ring member 2030 for engaging both the first and second retention grooves. As viewed in Fig. 29, the split ring member 2030 (constructed of a metal such as steel) has a gap 2040. The ring member 2030, when located in retention groove 2010, may flex radially outward when the cannula 11 is axially inserted into the sleeve part 1600 and into the ring member 1030. The outer surface 28 of the cannula 11 forces the ring member 2030 radially outward. The ring member 2030 then flexes back radially inward into the groove 2020 on the cannula 11 when the retention grooves 2010, 2020 are aligned. The ring member 2030 thereby axially secures the cannula 11 to the apparatus 1100.

As viewed in Figs. 30 and 31, the sleeve part 1600, cannula clamp 1500, and arm portion 1902 may be replaced in an apparatus 1100' by an alternative sleeve part 2100, a first arm portion 2110, and second arm portion 2120. The sleeve part 2100 is similar to the sleeve part 1600 of Figs. 19-29 except that it is not secured to the arm portion 1902 by the fasteners 1599. The sleeve part 2100 is a cylindrical

tube symmetric about a central axis. The first arm portion 2110 has a first end 2111 with a sleeve retainer comprising a ring member 2113, that is press fit onto an outer surface 2101 of the lower end of the sleeve part 2100. The first arm portion 2110 may be constructed of an electrically insulating material such as plastic so that no electric charge is carried across the first arm portion. The sleeve 2100 is thus electrically insulated from the second arm portion 2120.

A second end 2112 of the first arm portion 2110 is secured to one end 2121 of the second arm portion 2120 by fasteners 2119, such as bolts or rivets. The opposite end 2122 of the second arm portion 2120 has the same configuration as that of the arm portion 1902.

As viewed in Fig. 34, the sleeve part 1600 of Fig. 28 may, instead of the split ring member 2030, alternatively have two diametrically opposed slots 2051 for increasing radial flexibility of the sleeve part 1600. The outer surface 28 of the cannula 11 is slightly larger in diameter than the inner diameter of the inner surface 1611 of the sleeve part 1600. The cannula 11 is thereby frictionally secured within the sleeve part 1600 by the clamping engagement of the

sleeve part against the outer surface 28 of the cannula. The slots 2051 each have end portions 2052 that are open at the lower end of the sleeve part 1600.

As viewed in Fig. 32, the inner surface 1611 of the sleeve part 1600 may further include an internal annular bead 2061 for engaging the outer surface 28 of the cannula 11. The internal diameter of the bead 2061 may be less than the outer diameter of the cannula 11. When the cannula 11 is inserted into the sleeve part 1600, the internal diameter of the sleeve part 1600 and the internal bead 2061 may increase to accommodate the cannula. After a retention groove of the cannula 11 reaches alignment with the internal bead 2061 of the sleeve part 1600, the sleeve part can spring back toward its original diameter with the bead 2061 located in the retention groove on the cannula thereby axially securing the cannula within the sleeve part.

If the alternative internal bead feature 2061 is not used, a cannula with no groove may also be used. In this case the internal diameter of the sleeve 1600 may be less than the outer diameter of the cannula 11. Thus, the sleeve part 1600 would be expanded on

insertion of the cannula 11 and would grip the outer surface 28 of the cannula.

As viewed in Figs. 30, 31, and 32, the apparatus 1100' incorporates the alternative features of Figs. 28 and 29 into the apparatus of Figs. 19-27. The same numbering is applied to the apparatus 1100' as that applied to the apparatus 1100.

The entire apparatus 1100 or 1100' can be constructed from metal or any other suitable material having sufficient mechanical strength, flexibility, and durability. Certain parts may be made from materials permitting X-rays and other techniques for viewing the surgical site (i.e., radiopaque parts). Other parts may also be made from non-magnetic materials to reduce electromagnetic interference (i.e., electromagnetic insulating parts).

As viewed in Fig. 35, the cannula 11, the camera head 200, and the support apparatus 1100' of one embodiment is shown positioned for use in a surgical procedure such as spinal surgery. Similarly, a support apparatus of other embodiments also may be utilized with the cannula 11 and the camera head 200 for use in the surgical procedure illustrated in Fig. 35. While 75° and 90° angles of the cannula 11 are shown in

Figs. 5 and 35, the cannula 11 and associated devices may be adjusted to other suitable positions.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. Such improvements, changes and modifications within the skill of the art are intended to be covered by the appended claims.

Having described the invention, the following is claimed:

1. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, said apparatus comprising:

a base having a guide portion;

a part adapted to be fixed to the endoscope, said part engaging said guide portion and being movable relative to said guide portion; and

a screw mechanism connected between said base and said part, at least a portion of said screw mechanism being threaded into said base and being rotatable to slide said part relative to said guide portion to change a position of the endoscope relative to the patient.

2. The apparatus as defined in claim 1 further including a thumb wheel for rotating said portion of said screw mechanism to change the position of said part relative to said guide portion.

3. The apparatus as defined in claim 2 wherein said screw mechanism comprises a first threaded spindle rotatably screwed into first threads on said base, and a second threaded spindle fixed against rotation relative to said guide portion, said second threaded spindle being rotatably screwed into second threads on said first spindle, said thumb wheel rotating said first threaded spindle.

4. The apparatus as defined in claim 3 wherein said first threads and said second threads are of opposite hand.

5. The apparatus as defined in claim 1 wherein said part engages a track on said guide portion, said track allowing linear movement of said part relative to said base.

6. The apparatus as defined in claim 1 wherein said base further includes a base portion with a central aperture for receiving an end portion of a cannula.

7. The apparatus as defined in claim 1 wherein said base comprises a platform having an upper flat circular surface.

8. The apparatus as defined in claim 1 further including a cannula clamp associated with said base and a connection between said base and said cannula clamp, said connection enabling said base to rotate relative to said cannula clamp about an axis of a cannula.

9. The apparatus as defined in claim 8 wherein said connection includes an index mechanism for retaining said base at incremental angular positions about the axis of the cannula.

10. The apparatus as defined in claim 9 wherein said index mechanism includes a sleeve part, said sleeve part being disposed symmetrically about the axis of the cannula.

11. The apparatus as defined in claim 10 wherein said sleeve part includes a series of angularly spaced apart recesses and said base includes spaced apart members for receipt in said recesses for fixing the angular position of said base relative to the cannula.

12. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, the endoscope extending through a cannula into the patient, said apparatus comprising:

a base;

a support mechanism for supporting the endoscope on said base;

a cannula clamp for clamping against an outer surface of the cannula; and

a connection between said base and said cannula clamp, said connection enabling said base to rotate relative to said cannula clamp about an axis of the cannula, said connection including an index mechanism with parts interposed between said base and said cannula clamp for retaining said base at incremental relatively rotated positions relative to said cannula clamp.

13. The apparatus as defined in claim 12 wherein said parts of said index mechanism include a first part connected with one of said base and cannula clamp, said first part having a series of angularly spaced apart recesses, said parts of said index mechanism further including a second part connected with the other of said base and cannula clamp, said second part being received by said recesses.

14. The apparatus as defined in claim 13 wherein said base has a central aperture and said cannula clamp has a sleeve part secured thereto, said sleeve part being received in said central aperture, said sleeve part having said recesses, said base including spring biased detents on said base for receipt in said recesses.

15. The apparatus as defined in claim 14 wherein said sleeve part has a passage therethrough for receiving the cannula.

16. The apparatus as defined in claim 12 further including a part adapted to be fixed to the endoscope, said base including a guide portion, said part engaging said guide portion and being movable relative to said guide portion.

17. The apparatus as defined in claim 16 further including a screw mechanism connected between said base and said part, said screw mechanism being rotatable to slide said part relative to said guide portion.

18. The apparatus as defined in claim 16 wherein said guide portion includes two spaced apart upright members extending parallel to each other.

19. The apparatus as defined in claim 17 wherein said screw mechanism includes a first spindle with right-hand male threads and a second spindle with left-hand male threads.

20. The apparatus as defined in claim 12 wherein said cannula clamp includes an adjustment mechanism for allowing said cannula clamp to attach to cannulas of different sizes.

21. The apparatus as defined in claim 12 further including an actuating lever for actuating said cannula clamp to clamp against a cannula.

22. An apparatus associated with an endoscope for viewing a surgical site in a patient during surgery on the patient, the endoscope extending through a cannula into the patient, said apparatus comprising:

a cannula clamp including a pair of spaced apart arms for clamping against an outer surface of the cannula through which the endoscope extends; and

an actuator for moving said arms a predetermined distance toward each other to effect clamping against a cannula;

said cannula clamp further including an adjustment mechanism for changing the relative position of said arms from which said arms are moved by said actuator to enable said arms to clamp different diameter cannulas.

23. The apparatus as defined in claim 22 wherein said adjustment mechanism comprises a threaded member extending through openings in said arms, said arms being movable relative to said threaded member and a

knob threaded on said threaded member and which on rotation moves axially on said threaded member to change the relative positions of said arms.

24. The apparatus as defined in claim 22 further including a part adapted to be fixed to the endoscope and a base, said base including a guide portion, said guide portion engaging said part and allowing vertical movement of said part relative to said guide portion.

25. The apparatus as defined in claim 24 further including a screw mechanism connected between said base and said part.

26. The apparatus as defined in claim 25 wherein said screw mechanism is rotatable to slide said part relative to said guide portion.

27. The apparatus as defined in claim 25 further including a thumb wheel for rotating a portion of said screw mechanism.

28. The apparatus as defined in claim 24 wherein said guide portion includes a linear track for preventing rotation of said part relative to said base.

29. The apparatus as defined in claim 24 further including a screw mechanism for imparting vertical linear movement to the endoscope relative to a cannula.

30. The apparatus as defined in claim 22 further including a base for supporting the endoscope and an index mechanism for retaining said base at incremental relatively rotated positions relative to said cannula clamp.

31. The apparatus as defined in claim 22 wherein said cannula clamp is adapted to rotate and move linearly relative to the endoscope.

32. The apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, said apparatus comprising:

a part for engaging the endoscope, said part having a first surface portion for engaging opposed sides of the endoscope and a second surface portion spaced apart from said first surface portion for engaging a part of the endoscope defining a light port.

33. The apparatus as defined in claim 32 further including a base for supporting said part for axial movement of said part relative to an axis of a cannula.

34. The apparatus as defined in claim 33 wherein said base has a guide portion for guiding axial movement of said part and preventing rotation of said part relative to a cannula.

35. The apparatus as defined in claim 32 further including a cannula clamp associated with said base for clamping against an outer surface of a cannula.

36. The apparatus as defined in claim 35 wherein said cannula clamp includes two arms, and further including an adjustment mechanism for enabling said arms to clamp different diameter cannulas.

37. The apparatus as defined in claim 33 further including a screw mechanism associated with said base for axially moving said part to adjust the position of an endoscope relative to an axis of a cannula.

38. The apparatus as defined in claim 37 wherein said part includes a slot for receiving said screw mechanism and further including a threaded member connecting said part and said screw mechanism in said slot.

39. The apparatus as defined in claim 32 further including an index mechanism associated with said base for enabling incremental rotational adjustment of the position of said base and the endoscope relative to a cannula.

40. The apparatus as defined in claim 32 further including a base associated with said part and a mechanism for adjusting the position of the part and the endoscope relative to said base.

41. The apparatus as defined in claim 40 wherein said mechanism includes a sleeve for engaging an end of a cannula, said sleeve having an axis, said base and said sleeve being relatively rotatable about said axis of said sleeve.

42. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, said apparatus comprising:

a base for supporting the endoscope;

a first part adapted to be fixed to the endoscope;

a second part adapted to be fixed to a cannula with a longitudinal axis; and

a mechanism for axially and rotationally adjusting said first part relative to said second part, said mechanism including a member supported on said base for rotation on said base about an axis parallel

to the longitudinal axis of the cannula and spaced from the longitudinal axis of the cannula.

43. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, said apparatus comprising:

a cannula for insertion into a patient, said cannula having a longitudinal axis;

a cannula clamp for adjustably engaging an outer surface of said cannula;

a base supported for rotation relative to said cannula clamp about a longitudinal axis of said cannula; and

a part adapted to be fixed to an endoscope, said part being supported for linear movement on said base, the movement of said part being parallel to said longitudinal axis of said cannula.

44. An apparatus for supporting an endoscope that extends through a cannula for viewing a surgical site in a patient during surgery on the patient, said apparatus comprising:

a base for association with the cannula, said base having a guide portion;

a first part adapted to be fixed to the endoscope;

a second part engaging said guide portion and being movable relative to said guide portion, said first and second parts being movable together relative to said guide portion; and

a mechanism connected between said base and said second part for moving said first and second parts relative to said guide portion to change a position of the endoscope relative to the patient.

45. The apparatus as set forth in claim 44 further including a cannula retainer for engaging an outer surface of the cannula to secure the cannula to said cannula retainer, said cannula retainer including a split ring for engaging a groove on the outer surface of the cannula and a sleeve supporting said split ring.

46. The apparatus as set forth in claim 45 further including a connection between said base and said sleeve, said connection enabling said base to rotate relative to said sleeve about an axis of the cannula, said connection including an index mechanism with parts interposed between said base and said sleeve

for retaining said base at incremental relatively rotated positions relative to said sleeve.

47. The apparatus as set forth in claim 45 wherein said cannula retainer includes a sleeve for engaging an outer surface of the cannula, said sleeve and said base being relatively rotatable about an axis of the cannula.

48. The apparatus as set forth in claim 47 wherein said sleeve has an annular retaining lip for engaging an upper end of the cannula and limiting axial movement of the cannula relative to said sleeve, said annular retaining lip extending radially inward toward an axis of the cannula.

49. The apparatus as set forth in claim 47 further including a sleeve retainer for supporting said base and said sleeve, said sleeve retainer including a member press fit onto an end portion of said sleeve.

50. The apparatus as set forth in claim 44 further including a sleeve for engaging the cannula and a support arm for securing said sleeve to a support structure, said support arm including a first portion for connection to said sleeve and a second portion for interconnecting said first portion and the support structure, said first portion comprising an electrically insulating material electrically insulating said sleeve from said second portion.

51. The apparatus as set forth in claim 44 wherein said first part includes at least one rail member for slidably engaging a guide track of said second part.

52. The apparatus as set forth in claim 44 further including a cylindrical sleeve for receiving the cannula, said sleeve having at least one slot and an initial internal diameter that increases as the cannula is inserted into said sleeve such that said sleeve clamps against the cannula.

53. The apparatus as set forth in claim 44 wherein said mechanism includes a first threaded spindle and a second threaded spindle rotatable about an axis relative to said first threaded spindle, said first threaded spindle having a lip portion for limiting axial displacement of said first threaded spindle relative to said second threaded spindle.

54. The apparatus as set forth in claim 53 wherein said second threaded spindle has a radially extending shoulder portion for engaging said lip portion of said first threaded spindle.

55. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, the endoscope extending through a cannula into the patient, said apparatus comprising:

a base; and

a cannula retainer for engaging an outer surface of the cannula to secure the cannula to said cannula retainer, said cannula retainer including a split ring for engaging a groove on the outer surface of the cannula and a sleeve for receiving the cannula and supporting said split ring,

said base being rotatable relative to said sleeve about an axis of the cannula.

56. The apparatus as set forth in claim 55 wherein said base includes a guide portion, and further including a first part to be fixed to the endoscope and a second part engaging said guide portion, said first and second parts being movable together relative to said guide portion.

57. The apparatus as set forth in claim 55 further including a sleeve retainer for supporting said base and said sleeve, said sleeve retainer including a ring member press fit onto an end portion of said sleeve.

58. The apparatus as set forth in claim 55 wherein said sleeve has at least one slot and an initial internal diameter that increases as the cannula is inserted into said sleeve such that said sleeve clamps against the cannula.

59. The apparatus as set forth in claim 55 wherein said sleeve has an annular retaining lip for engaging an upper end of the cannula and limiting axial movement of the cannula relative to said sleeve.

60. The apparatus as set forth in claim 58 wherein said sleeve includes an annular bead disposed on an inner surface of said sleeve, said annular bead being adapted to secure the cannula to said sleeve.

61. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, the endoscope extending through a cannula into the patient, said apparatus comprising:

a base for supporting the endoscope;

a sleeve for engaging an outer surface of the cannula, said base and said sleeve being relatively rotatable about an axis of the cannula; and

a sleeve retainer for supporting said sleeve and said base, said sleeve retainer including a member press fit onto an end portion of said sleeve.

62. The apparatus as set forth in claim 61 further including a first part to be fixed to the endoscope and a second part for slidably engaging said base, said first part and said second part being vertically movable together relative to said base.

63. The apparatus as set forth in claim 61 wherein said sleeve is a part of a cannula retainer, said cannula retainer further including a split ring for engaging a first groove on the outer surface of the cannula and for engaging a second groove on an inner surface of said sleeve.

64. The apparatus as set forth in claim 61 further including a connection between said base and said sleeve, said connection enabling said base to rotate relative to said sleeve about the axis of the cannula, said connection including an index mechanism with parts interposed between said base and said sleeve for retaining said base at incremental relatively rotated positions relative to said sleeve.

65. The apparatus as set forth in claim 61 wherein said sleeve retainer comprises an electrically insulating material electrically insulating said sleeve.

66. The apparatus as set forth in claim 61 wherein said sleeve has an initial internal diameter that increases as the cannula is inserted into said sleeve such that the sleeve clamps against the cannula.

67. The apparatus as set forth in claim 61 further including a mechanism for axially adjusting the endoscope relative to said base, said mechanism including a first threaded spindle and a second threaded spindle rotatable about an axis relative to said first threaded spindle, said first threaded spindle having a lip portion for limiting axial displacement of said first threaded spindle relative to said second threaded spindle.

68. The apparatus as set forth in claim 67 wherein said second threaded spindle has a radially extending shoulder portion for engaging said lip portion of said first threaded spindle.

69. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, the endoscope extending into a cannula and into the patient, said apparatus comprising:

a base for supporting the endoscope;

a sleeve for engaging an outer surface of the cannula, said base and said sleeve being relatively rotatable about an axis of the cannula; and

a support arm for securing said sleeve to a support structure, said support arm including a first portion for connection to said sleeve and a second portion for interconnecting said first portion and the support structure, said first portion comprising an electrically insulating material electrically insulating said sleeve from said second portion.

70. The apparatus as set forth in claim 69 further including a first part to be fixed to the endoscope and a second part adjustably engaging said base, said first part and said second part being vertically movable together relative to said base.

71. The apparatus as set forth in claim 70 wherein said sleeve has an annular retaining lip for engaging an upper end of the cannula and limiting axial movement of the cannula relative to said sleeve, said annular retaining lip extending radially inward toward the axis of the cannula.

72. The apparatus as set forth in claim 69 wherein said sleeve is part of a cannula retainer, said cannula retainer further including a split ring for engaging a first groove on the outer surface of the cannula and a second groove on an inner surface of said sleeve.

73. The apparatus as set forth in claim 72 further including a connection between said base and said sleeve, said connection enabling said base to rotate relative to said sleeve about the axis of the cannula, said connection including an index mechanism with parts interposed between said base and said sleeve for retaining said base at incremental relatively rotated positions relative to said sleeve.

74. The apparatus as set forth in claim 69 wherein said sleeve has an annular bead and at least one slot such that an initial internal diameter of said annular bead can increase as the cannula is inserted into said sleeve and subsequently spring back toward said initial diameter.

75. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, said apparatus comprising:

a base having a guide portion;

a first part to be fixed to an endoscope, a second part movable in said guide portion and connected with said first part, said first and second parts being movable together relative to said guide portion;

a screw mechanism connected to said second part and operable to move said first and second parts relative to said guide portion; and

a pin for securing said second part to said screw mechanism, said pin being press fit into recesses in both said second part and said screw mechanism.

76. The apparatus as set forth in claim 75 further including a cannula retainer engaging an outer surface of a cannula and securing said cannula to said cannula retainer, said cannula retainer including a sleeve for receiving said cannula and a split ring for engaging a groove on said outer surface of said cannula.

77. The apparatus as set forth in claim 76 wherein said sleeve has an annular retaining lip for engaging an upper end of the cannula and limiting axial movement of the cannula relative to said sleeve.

78. The apparatus as set forth in claim 76 further including a connection between said base and said sleeve, said connection enabling said base to rotate relative to said sleeve about an axis of said sleeve, said connection including an index mechanism with parts interposed between said base and said cannula for retaining said base at incremental relatively rotated positions relative to said sleeve.

79. The apparatus as set forth in claim 75 further including a sleeve for engaging an outer surface of a cannula, said sleeve and said base being relatively rotatable about an axis of the cannula.

80. The apparatus as set forth in claim 79 further including a sleeve retainer for supporting said sleeve and said base, said sleeve retainer including a ring member press fit onto an end portion of said sleeve.

81. The apparatus as set forth in claim 75 further including a cylindrical sleeve for engaging an outer surface of a cannula, said sleeve having an internal bead having an internal diameter that increases from an initial diameter as the cannula is inserted into said sleeve and that subsequently springs back toward said initial diameter.

82. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, the endoscope extending through a cannula into the patient, said apparatus comprising:

a base for supporting the endoscope;

a sleeve for engaging an outer surface of the cannula, said base and said sleeve being relatively rotatable about an axis of the cannula; said sleeve having an internal diameter that increases from an initial diameter as the cannula is inserted into said sleeve and that subsequently springs back toward said initial diameter so that said sleeve grips the cannula.

83. The apparatus as set forth in claim 82 wherein said sleeve is part of a cannula retainer, said cannula retainer further including a split ring for engaging a groove on the outer surface of the cannula.

84. The apparatus as set forth in claim 83 further including a connection between said base and said sleeve, said connection enabling said base to rotate relative to said sleeve about the axis of the cannula, said connection including an index mechanism with parts interposed between said base and said sleeve for retaining said base at incremental relatively rotated positions relative to said sleeve.

85. The apparatus as set forth in claim 82 further including a sleeve retainer for supporting said base and said sleeve, said sleeve retainer including a ring member press fit onto an end portion of said sleeve.

86. The apparatus as set forth in claim 82 further including a support arm for securing said sleeve to a support structure, said support arm including a first portion for connection to said sleeve and a second portion for interconnecting said first portion and the support structure, said first portion comprising an electrically insulating material electrically insulating said sleeve from said second portion.

87. An apparatus for supporting an endoscope for viewing a surgical site in a patient during surgery on the patient, said apparatus comprising:

a base having a guide portion;

a structure adapted to be fixed to the endoscope, said structure engaging said guide portion and being movable relative to said guide portion; and

a screw mechanism connected between said base and said structure, at least a portion of said screw mechanism being rotatable to slide said structure relative to said guide portion to change a position of the endoscope relative to the patient,

said screw mechanism including a first threaded spindle having female threads and a second threaded spindle rotatable about an axis relative to said female threads in said first threaded spindle, said first threaded spindle having a lip portion for limiting axial displacement of said first threaded spindle relative to said second threaded spindle.

88. The apparatus as set forth in claim 87 wherein said structure comprises a first part adapted to be fixed to the endoscope and a second part vertically movable relative to said guide portion, said first and second parts being movable together relative to said guide portion.

89. The apparatus as set forth in claim 87 further including a sleeve engaging an outer surface of a cannula, and a split ring supported by said sleeve for engaging a groove on said outer surface of said cannula.

90. The apparatus as set forth in claim 89 further including a connection between said base and said sleeve, said connection enabling said base to rotate relative to said sleeve about an axis of said cannula, said connection including an index mechanism with parts interposed between said base and said cannula for retaining said base at incremental relatively rotated positions relative to said cannula.

91. The apparatus as set forth in claim 89 further including a sleeve retainer for supporting said base and said sleeve, said sleeve retainer including a ring member press fit onto an end portion of said sleeve.

92. An apparatus for supporting an endoscope for viewing a surgical site in a patient through a cannula defining an axis and at least partially disposed within the patient, said endoscope configured to extend within an interior portion of said cannula, the apparatus comprising:

a base having a guide portion and defining an aperture therethrough for communication with said interior portion of said cannula positioned adjacent to said base;

a part adapted for mounting to said endoscope, said part engaging said guide portion and being movable relative to said guide portion; and

an axial adjustment mechanism positioned between said base and said part, at least a portion of said axial adjustment mechanism being rotatable to effect movement of said part relative to said guide portion and to axially move said endoscope mounted to said part relative to said aperture in said base.

93. The apparatus according to claim 92, further comprising a cannula clamp structure mounted to said base for retaining said cannula adjacent to said aperture in said base.

94. The apparatus according to claim 93, further comprising an angular adjustment mechanism positioned between said base and said cannula clamp structure to permit angular rotation of said cannula clamp structure relative to said base.

95. The apparatus according to claim 94, wherein said angular adjustment mechanism further comprises a plurality of detents to releasably retain said base and said cannula clamp structure in a plurality of relative angular positions.

96. The apparatus according to claim 92, wherein said base further comprises a flat platform surrounding said aperture.

97. The apparatus according to claim 96, wherein said flat platform is a substantially circular disk.

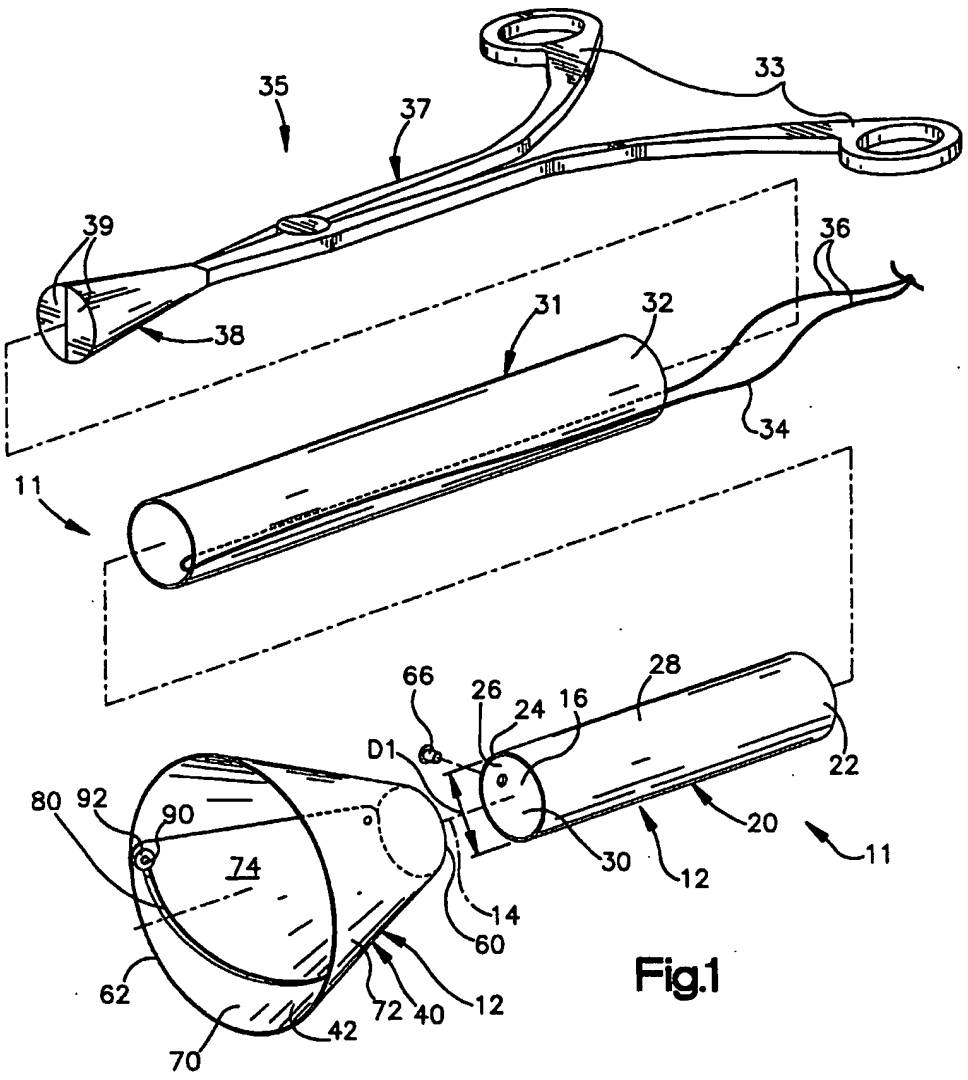

35
37
33
39
36
38
31
32
34
11
66
26
24
16
28
D1
22
80
92
90
74
20
30
12
11
14
60
62
72
40
12
42
70

Fig.1

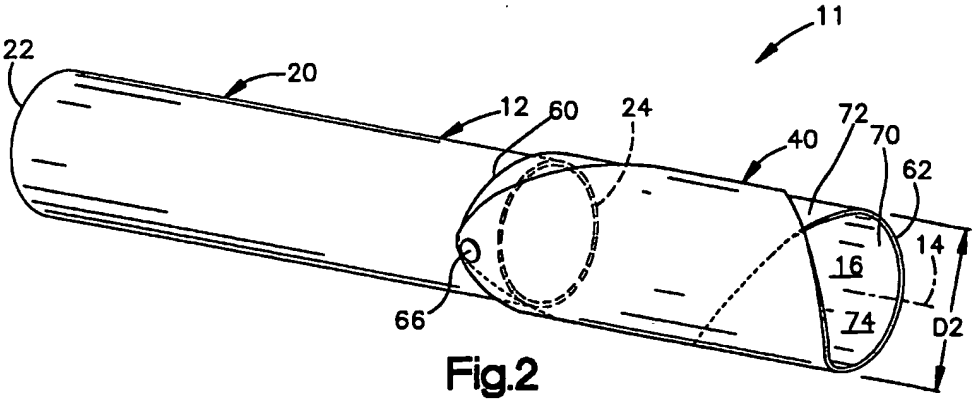

11
22
20
12
60
24
72
40
70
62
14
16
74
D2
66

Fig.2

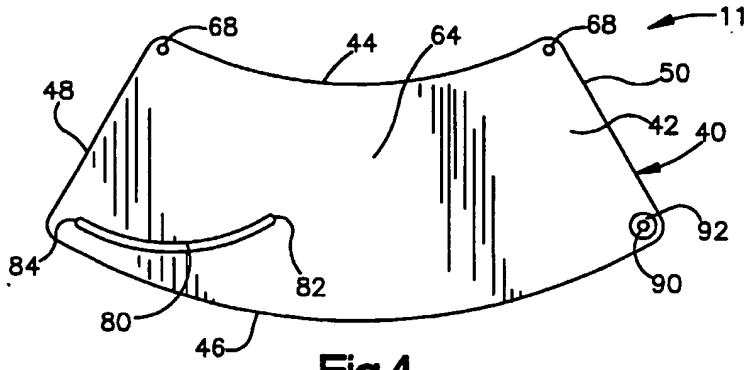


Fig.4

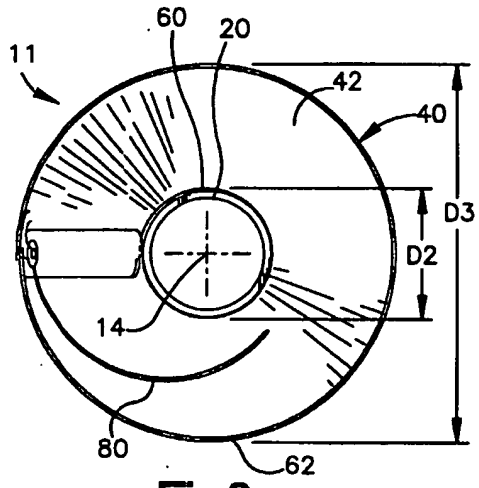


Fig.3

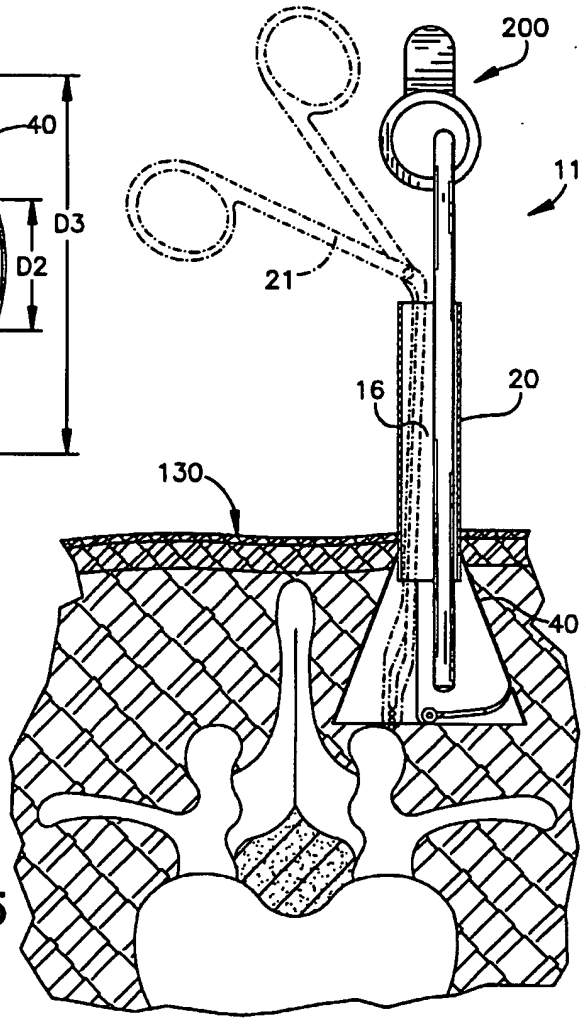


Fig.5

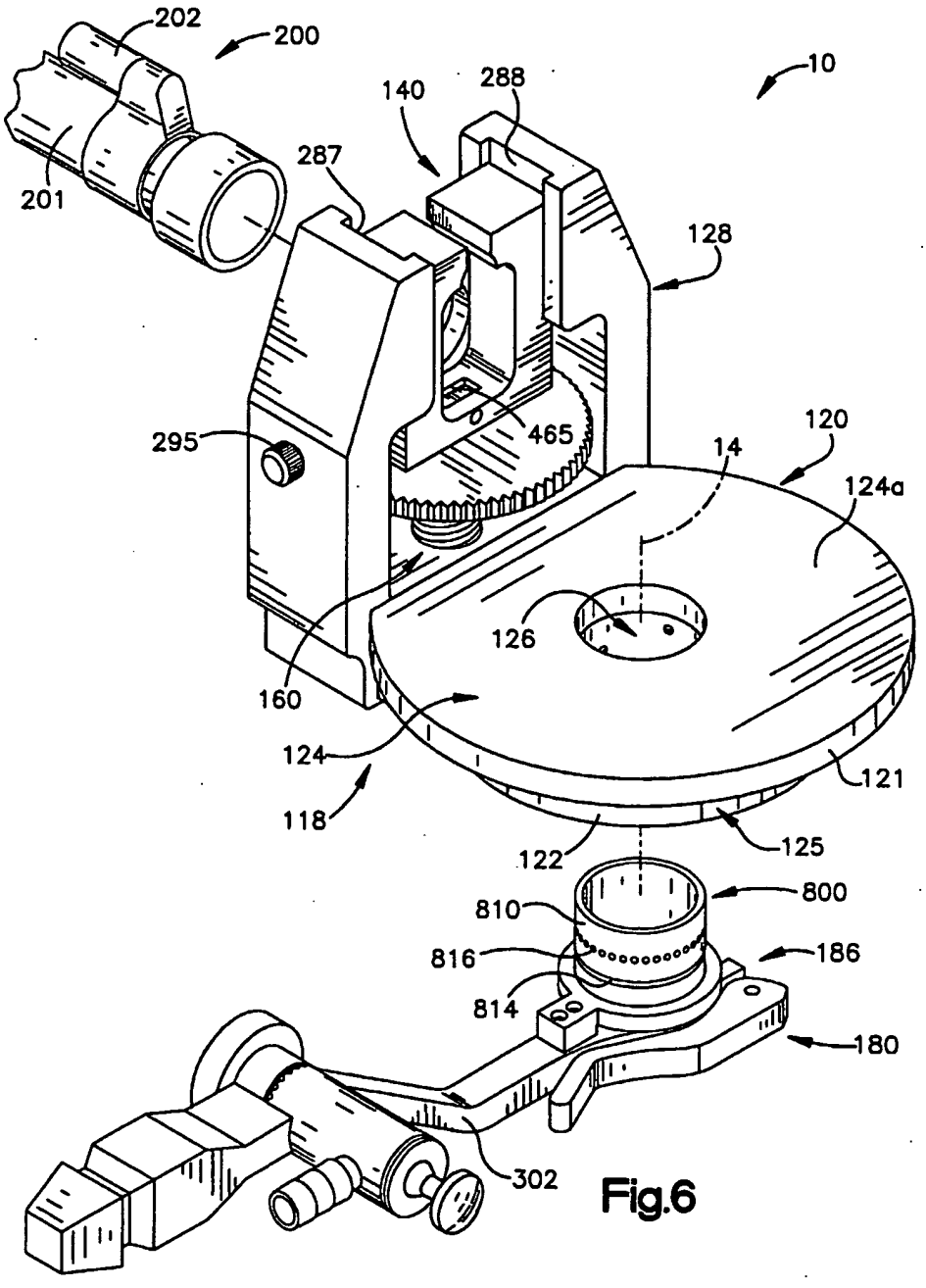

202
200
10
140
288
287
201
128
295
465
120
14
124a
126
160
124
121
118
122
125
800
810
816
186
814
180
302

Fig.6

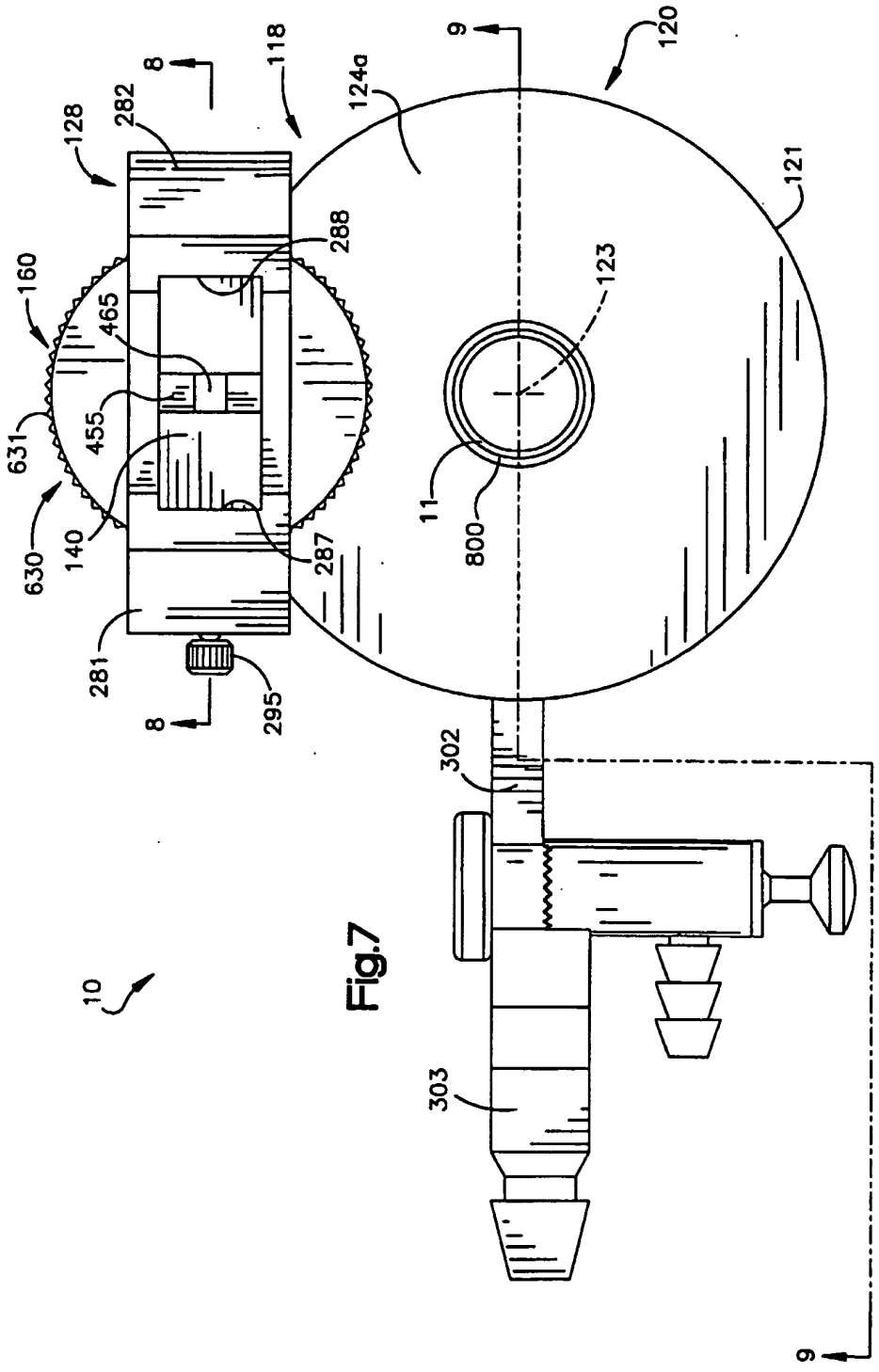

8
118
9
120
124a
128
282
121
288
123
160
465
455
631
11
800
630
140
287
281
295
8
302
303
10
9

Fig.7

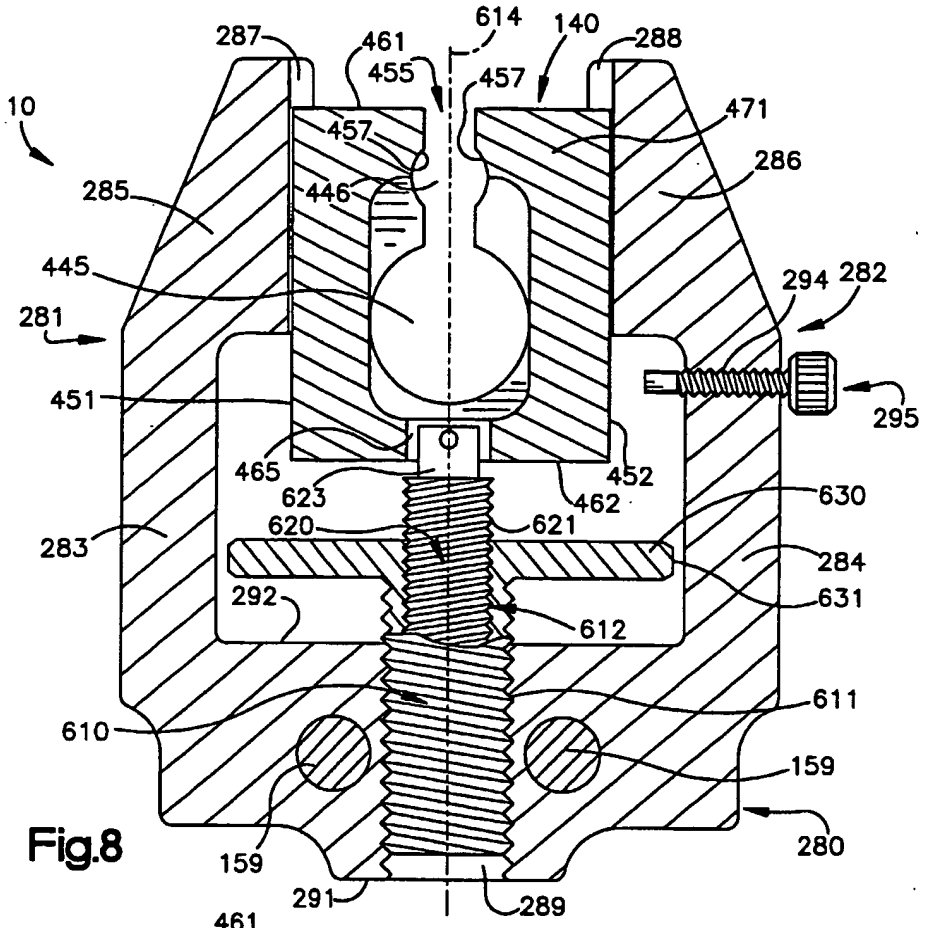


Fig.8

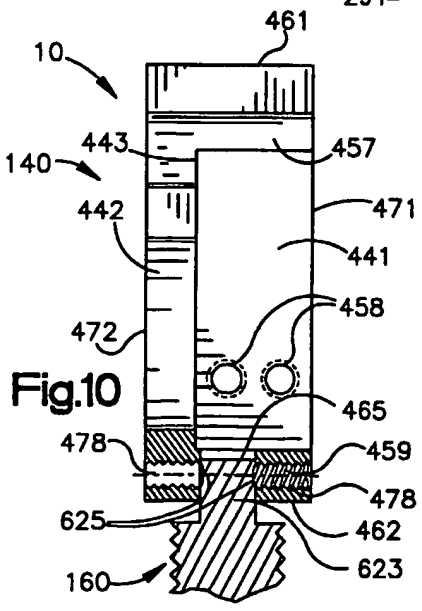


Fig.10

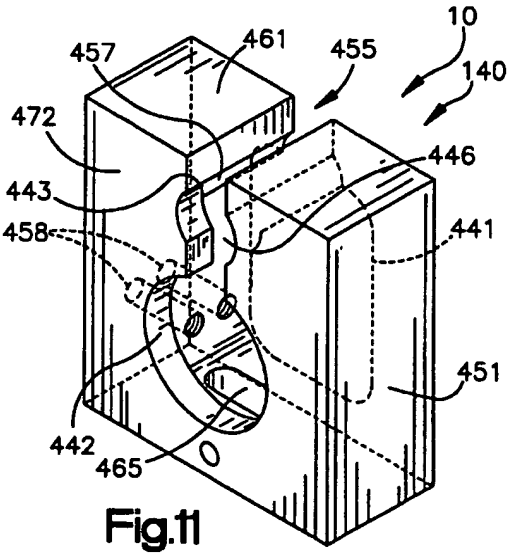


Fig.11

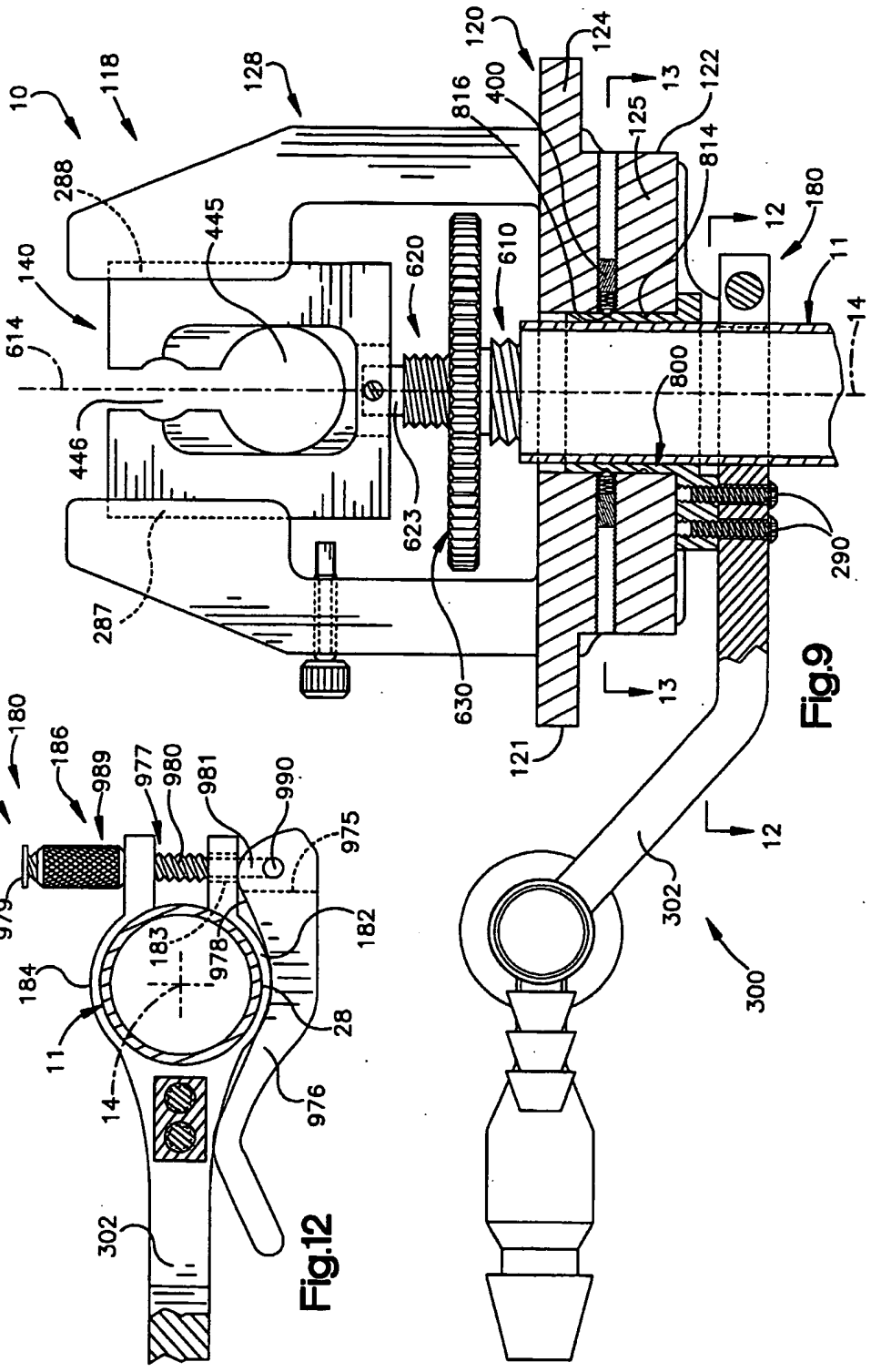

10
118
128
120
124
816
400
13
122
125
814
288
445
620
610
12
180
11
140
614
14
800
446
623
290
287
630
13
121
12
302
300
180
10
186
989
977
980
981
990
975
979
182
183
978
184
28
11
14
976
302

Fig.9

Fig.12

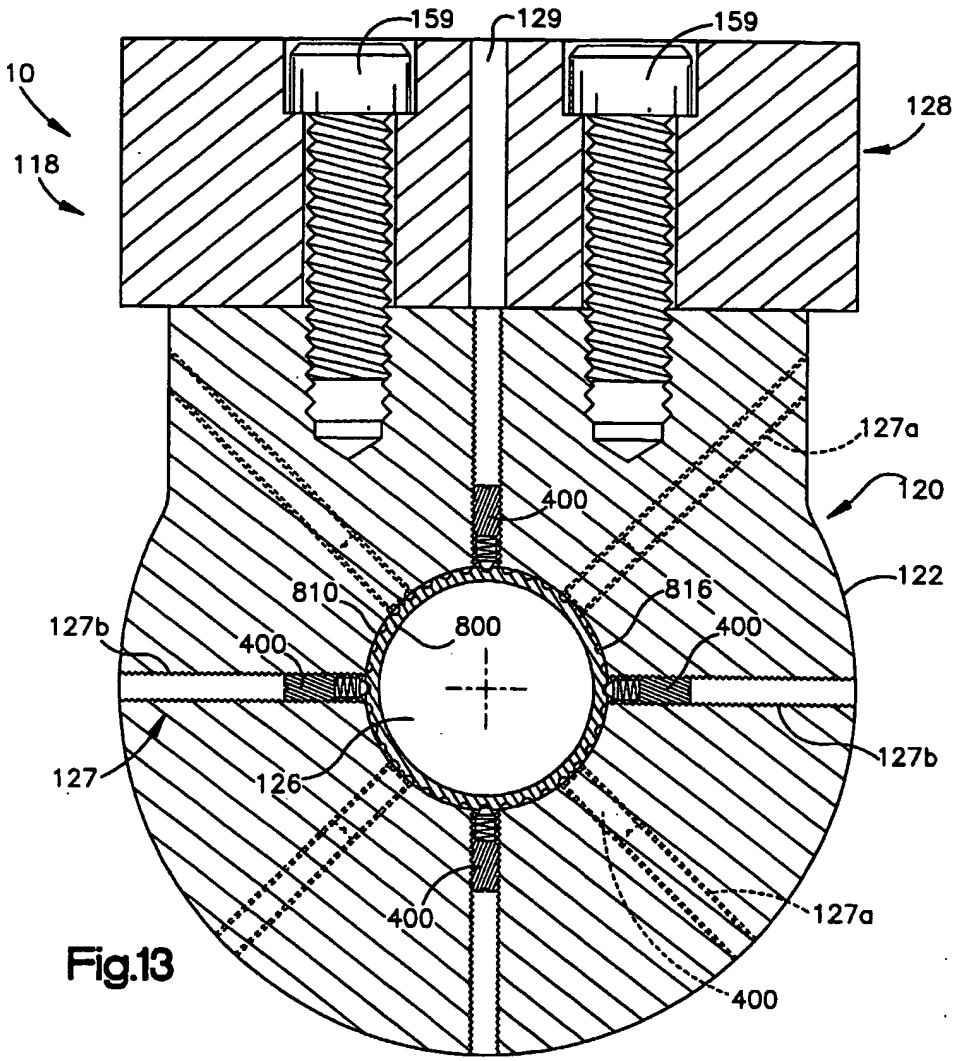

159
129
159
10
128
118
127a
120
400
122
810
816
800
400
127b
400
127
126
127b
400
127a
400

Fig.13

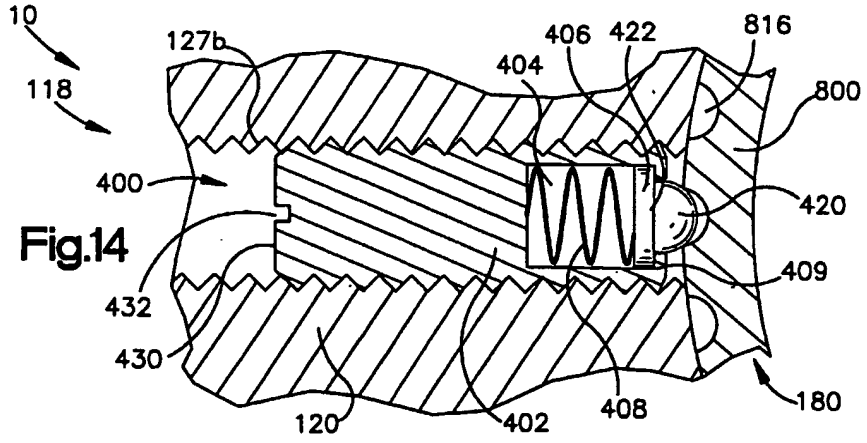

10
127b
406
422
816
404
118
800
400
420
409
432
430
120
402
408
180

Fig.14

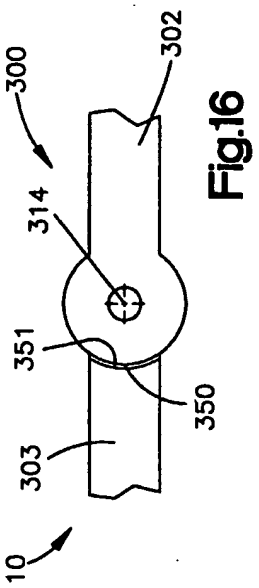


Fig.16

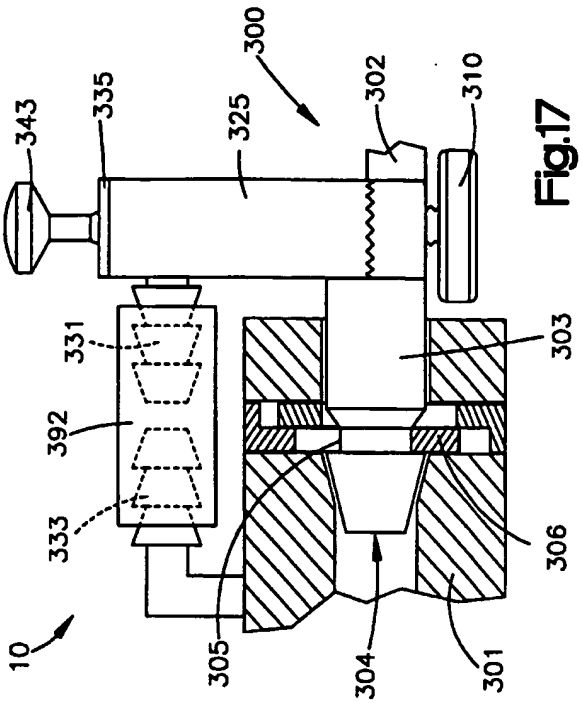


Fig.17

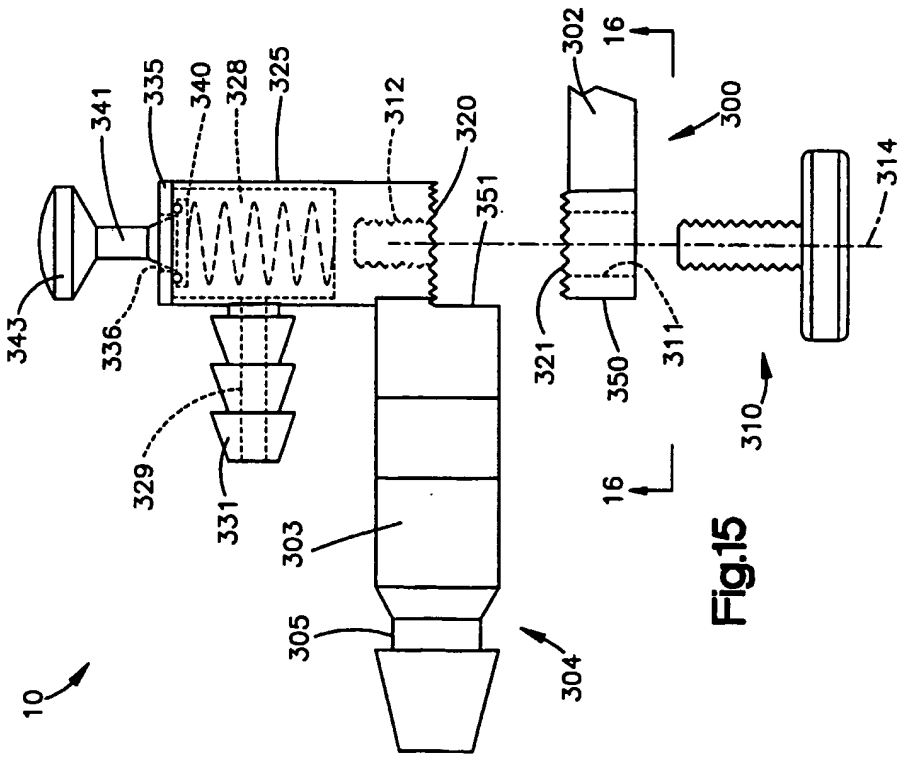


Fig.15

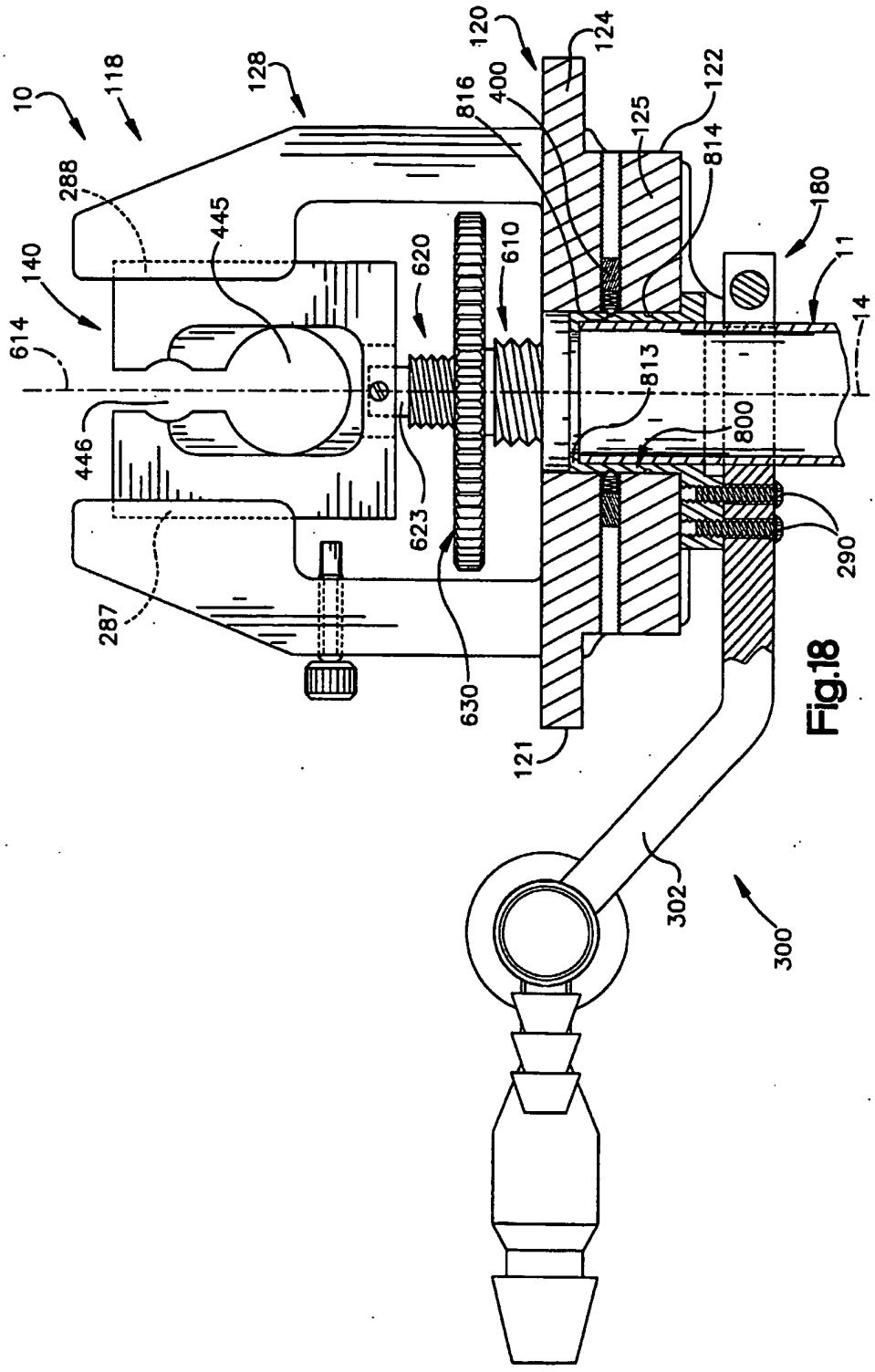

10
118
128
120
124
816
400
122
125
814
180
11
14
288
445
140
620
610
614
813
800
446
623
290
287
630
121
302
300

Fig.18

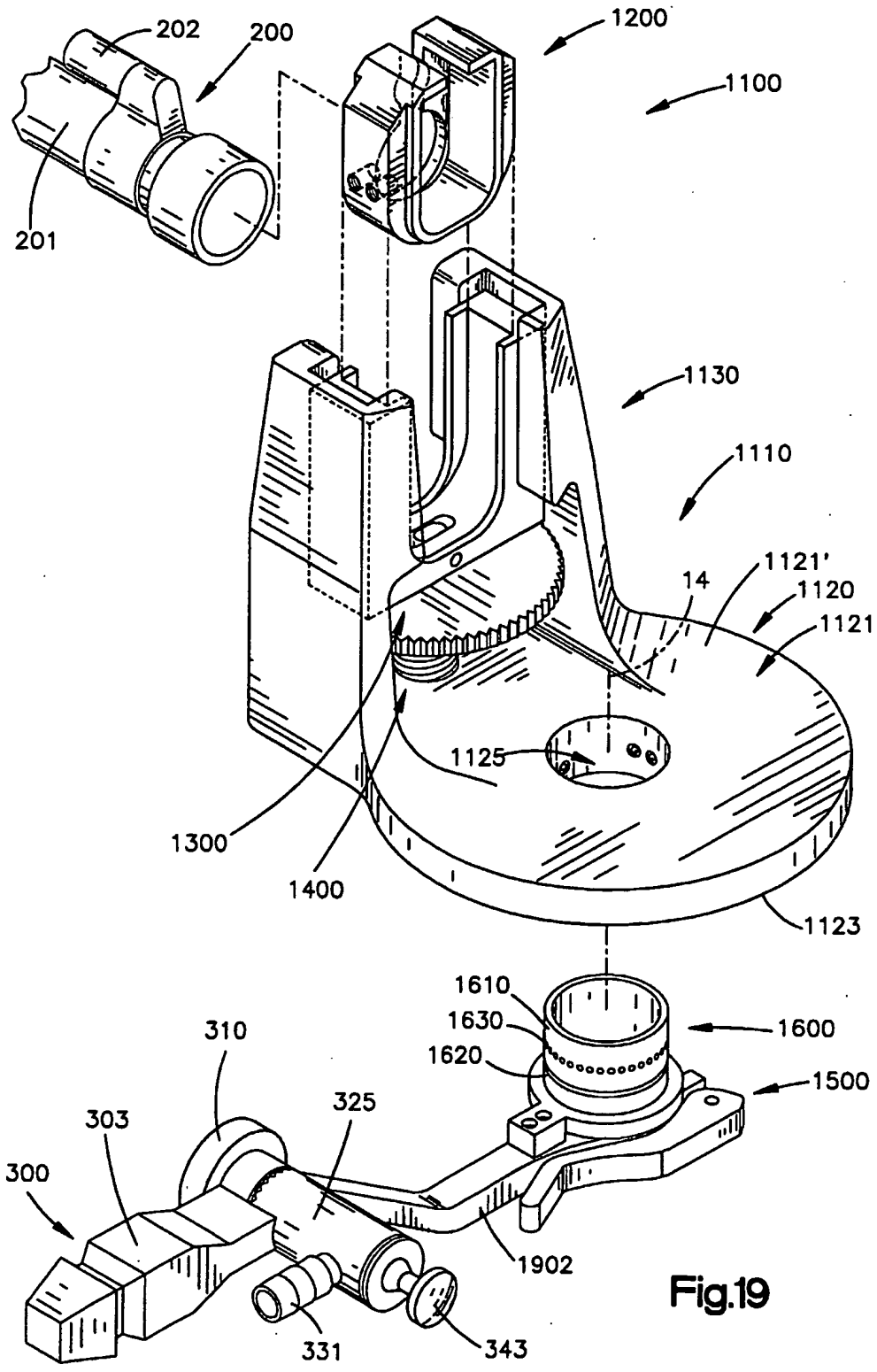

202
200
1200
1100
201
1130
1110
1121'
14
1120
1121
1125
1300
1400
1123
1610
1630
1620
1600
1500
310
303
325
300
1902
331
343

Fig.19

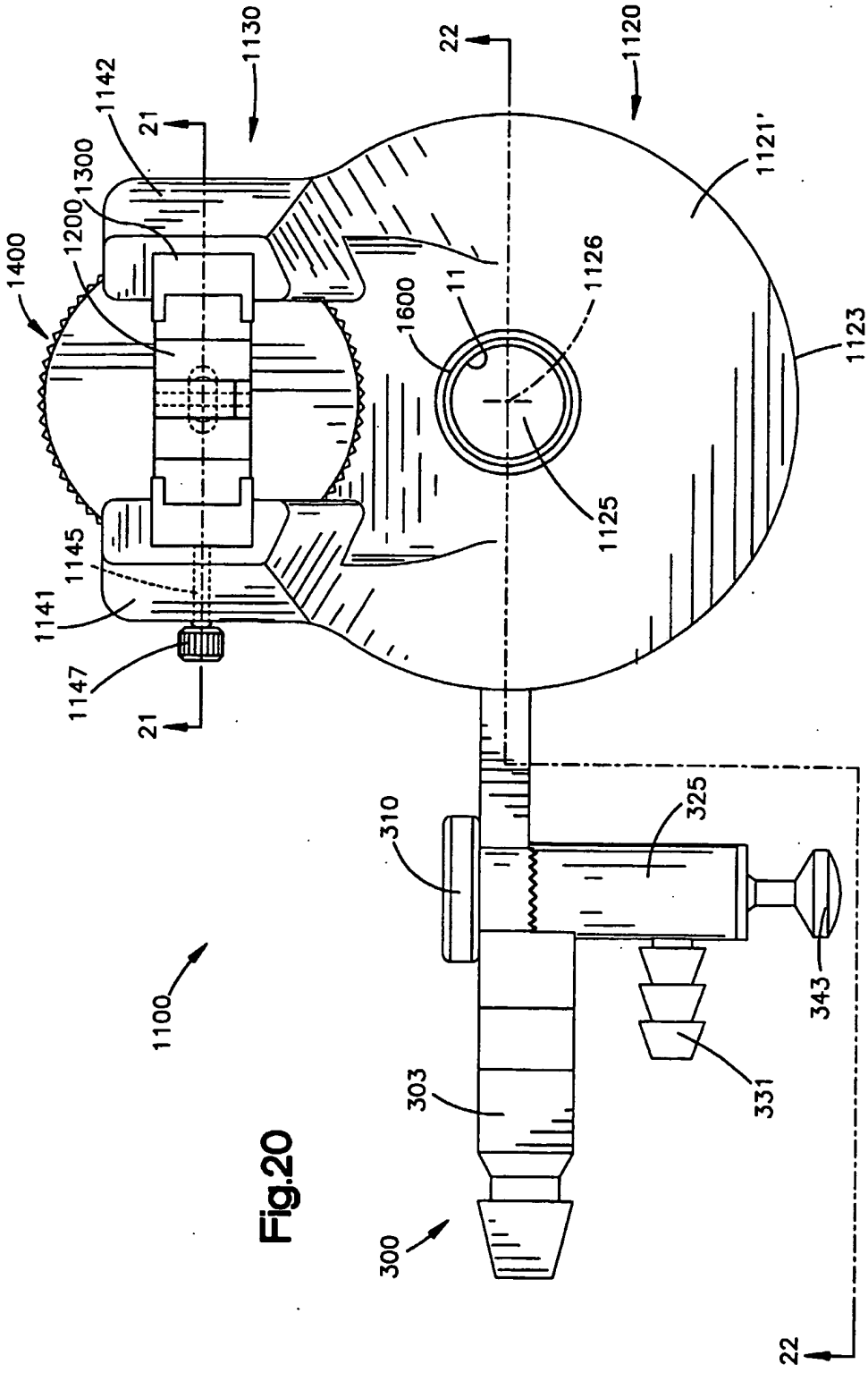

1130
22
1120
1142
21
1121'
1300
1200
1400
1126
1600
11
1123
1125
1145
1141
1147
21
310
325
1100
343
303
331
300
22

Fig.20

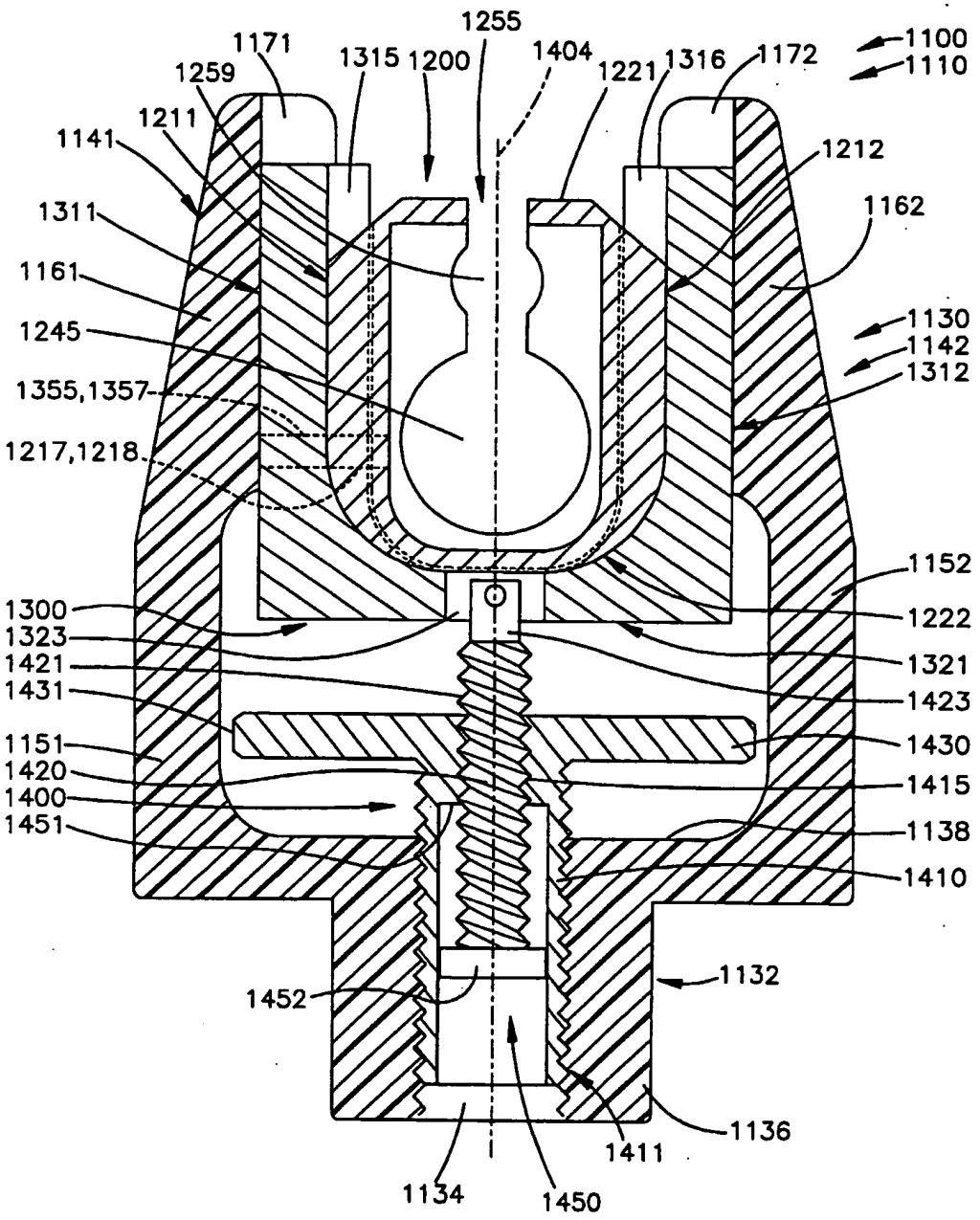

1255
1171
1315
1200
1404
1221
1316
1172
1100
1110
1259
1211
1141
1212
1311
1162
1161
1130
1245
1142
1355,1357
1312
1217,1218
1152
1300
1222
1323
1321
1421
1423
1431
1151
1430
1420
1415
1400
1138
1451
1410
1132
1452
1136
1411
1134
1450

Fig.21

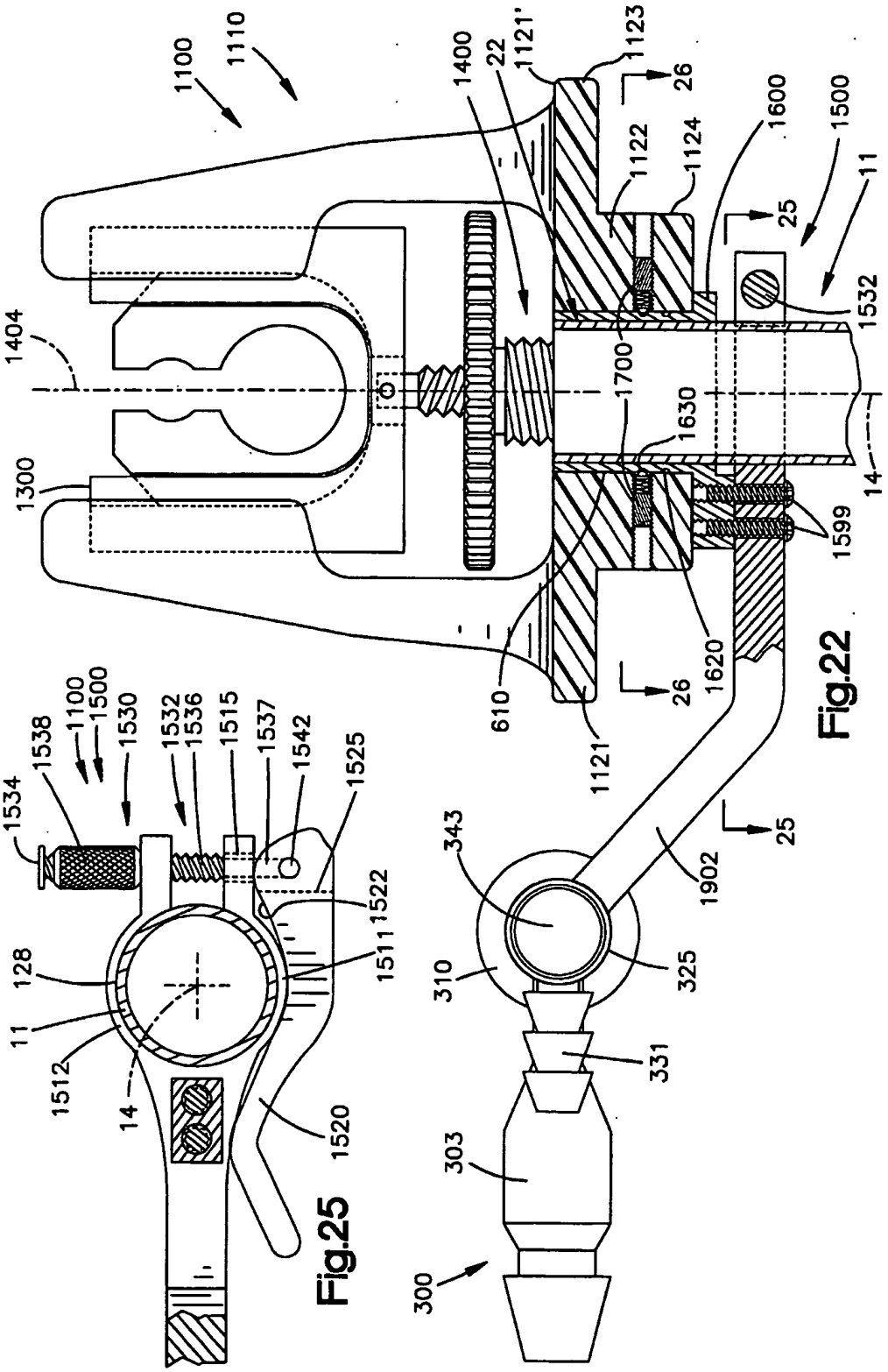

1100
1110
1400
22
1121'
1123
26
1122
1124
1600
1500
11
25
1532
1404
1700
1630
1300
14
1599
610
1620
1121
26
25
1902
343
325
310
331
303
300
1538
1534
1100
1500
1530
1532
1536
1515
1537
1542
1525
1522
1511
128
11
1512
14
1520

Fig.22

Fig.25

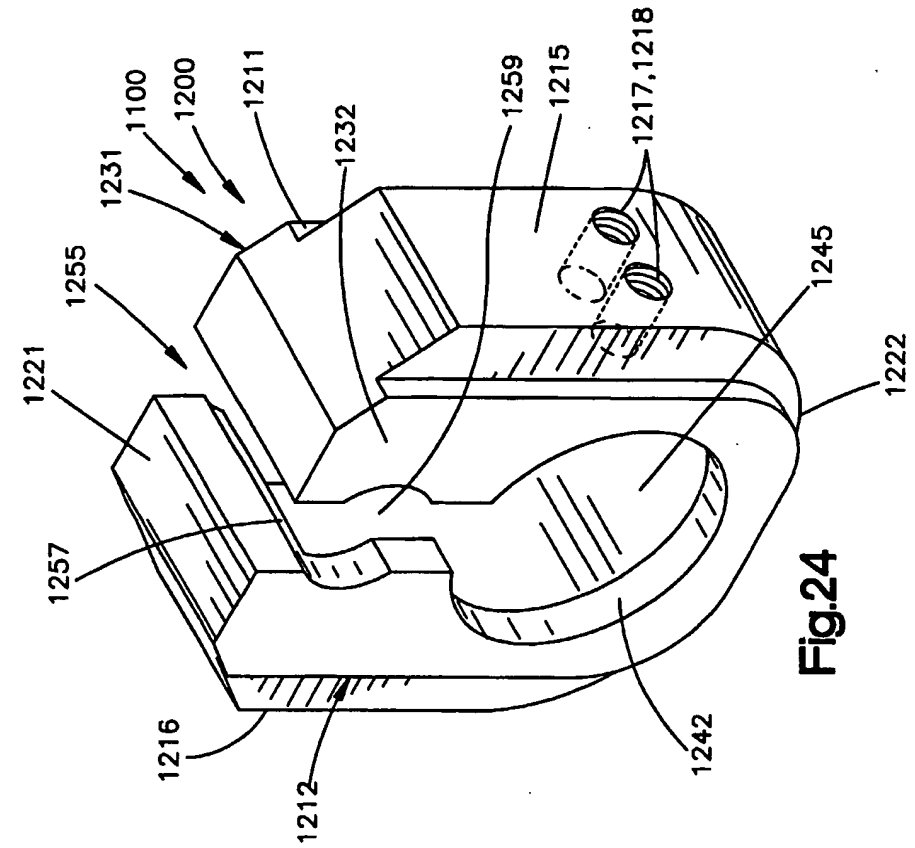

1100
1200
1211
1232
1259
1215
1217,1218
1231
1255
1245
1221
1222
1257
1216
1212
1242

Fig.24

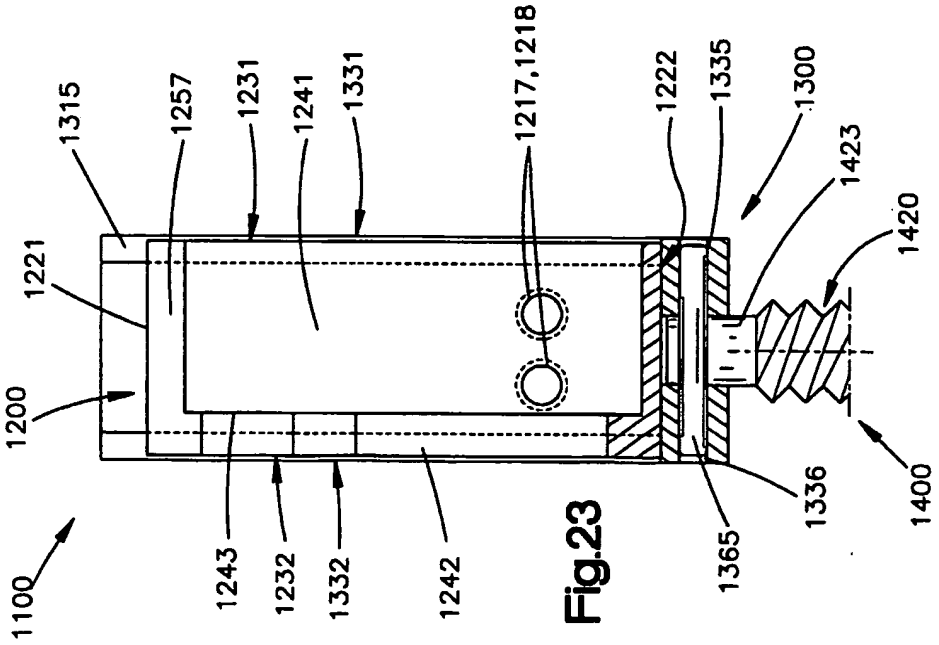

1315
1257
1231
1241
1331
1217,1218
1222
1335
1300
1423
1420
1221
1200
1100
1243
1232
1332
1242
1365
1336
1400

Fig.23

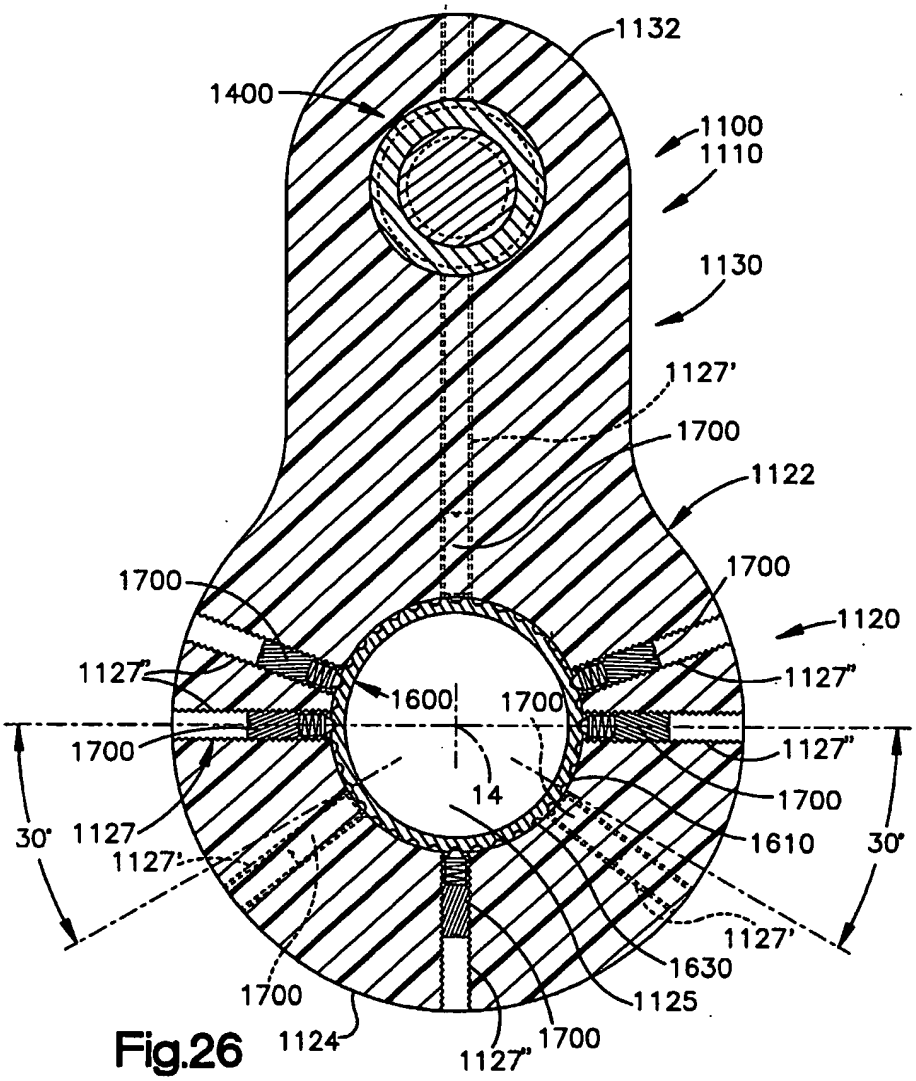

1132
1400
1100
1110
1130
1127'
1700
1122
1700
1700
1120
1127"
1600
1700
1127"
1700
1127"
14
1700
30°
1127
1127'
1610
30°
1127'
1630
1700
1125
1124
1127"
1700

Fig.26

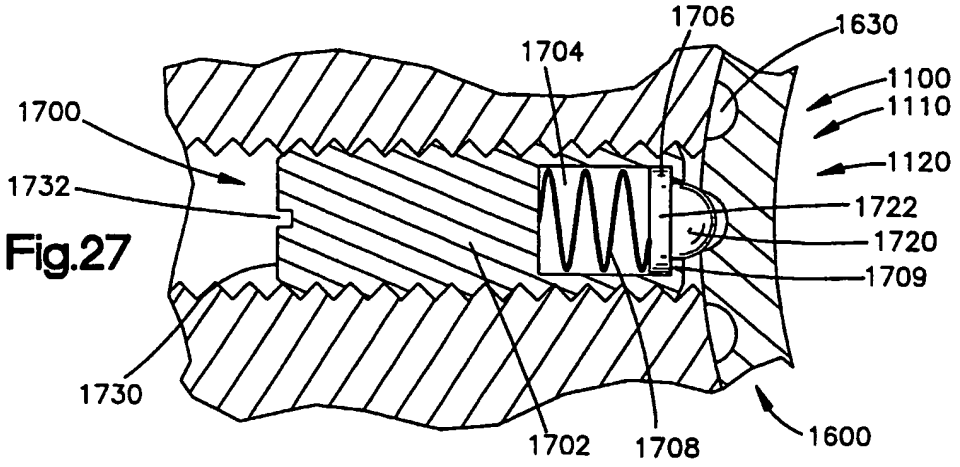

1706
1630
1704
1100
1110
1700
1120
1732
1722
1720
1709
1730
1702
1708
1600

Fig.27

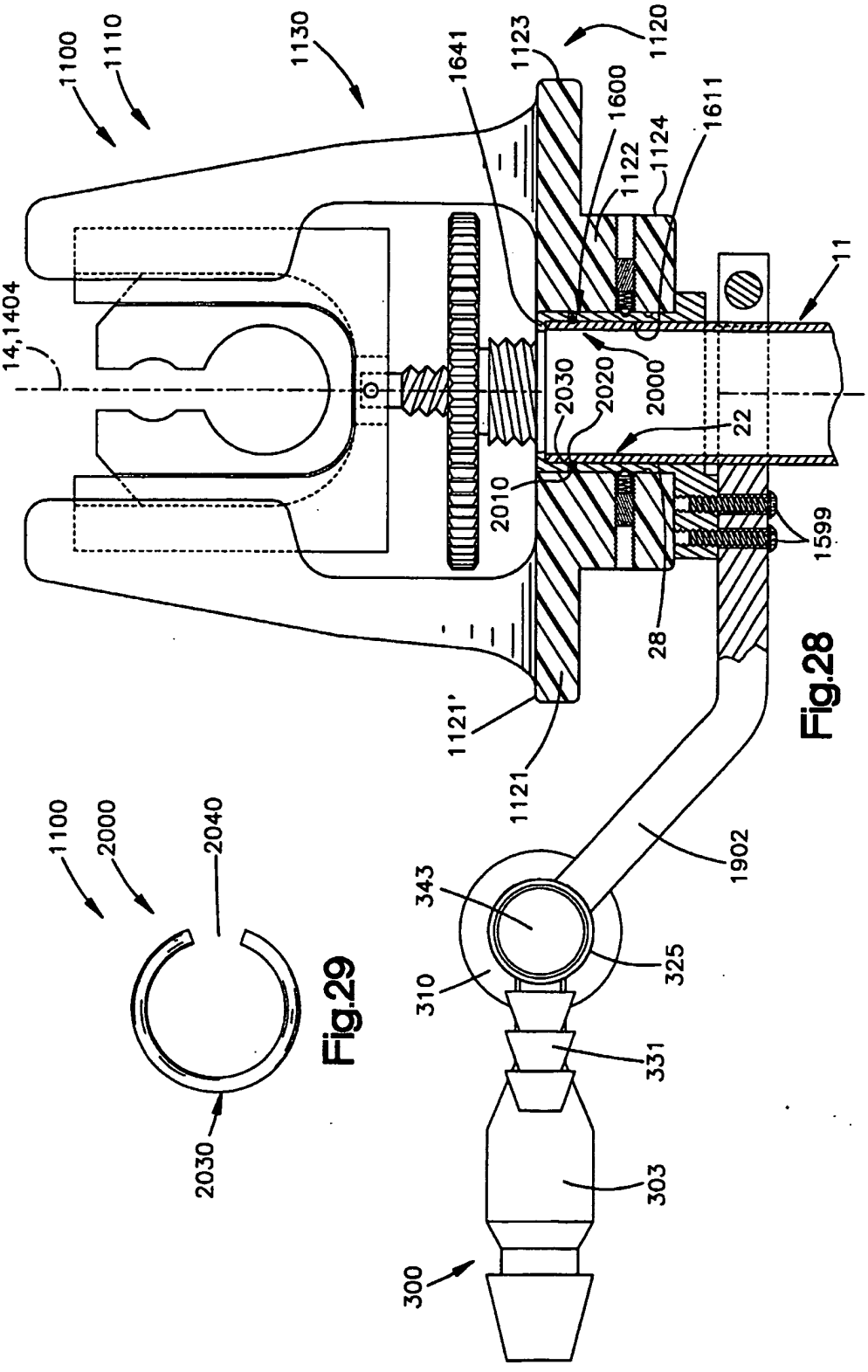

1100
1110
1130
1641
1123
1120
1600
1611
1124
1122
11
14,1404
2030
2020
2000
22
2010
1599
28
1121'
1121
1902
343
325
310
331
303
300

Fig.28

1100
2000
2040
2030

Fig.29

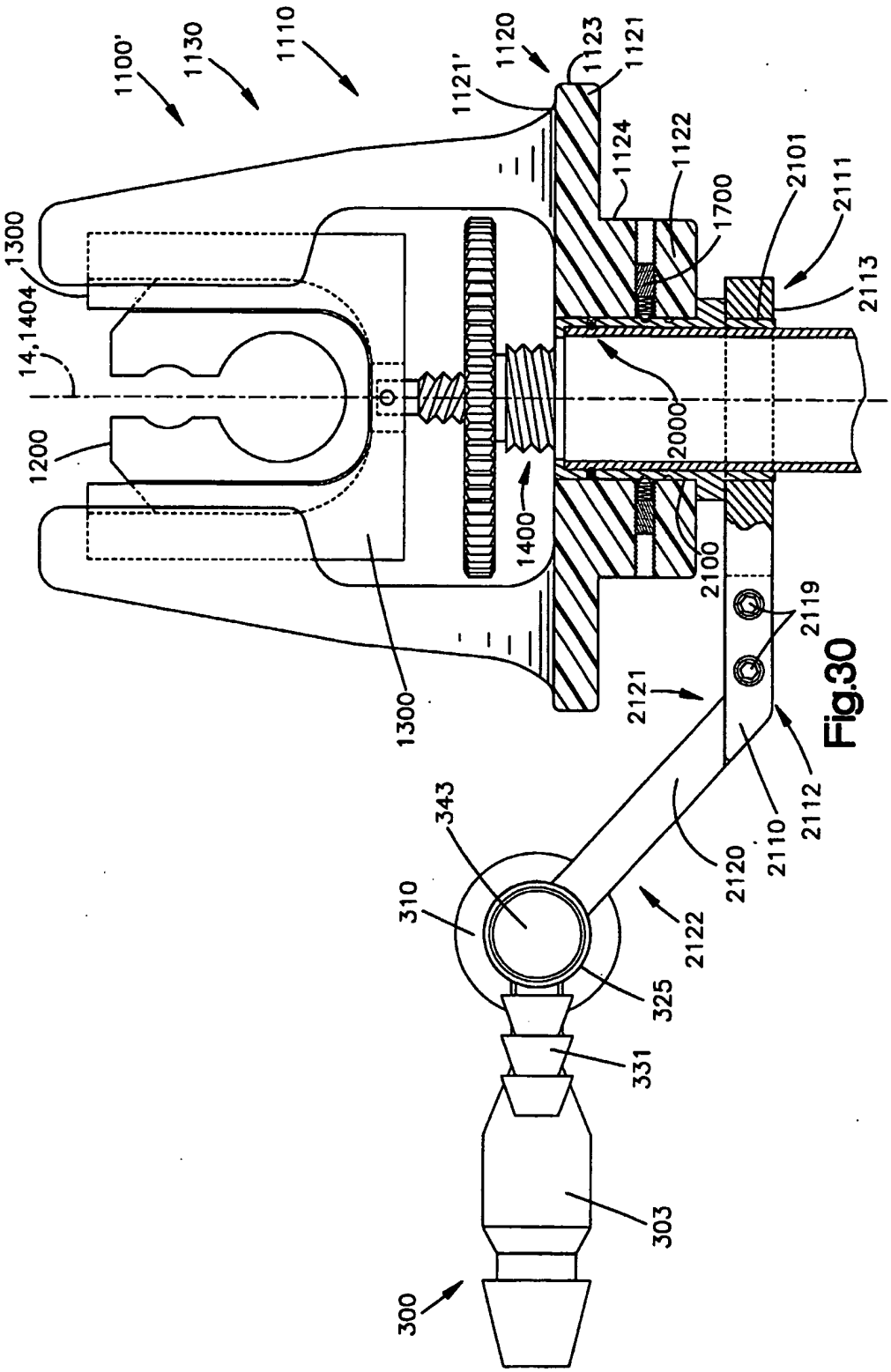

1100'
1130
1110
1120
1123
1121
1121'
1124
1122
2101
2111
1700
2113
1300
14,1404
2000
1200
1400
2100
2119
1300
2121
2112
343
2110
2120
310
2122
325
331
303
300

Fig.30

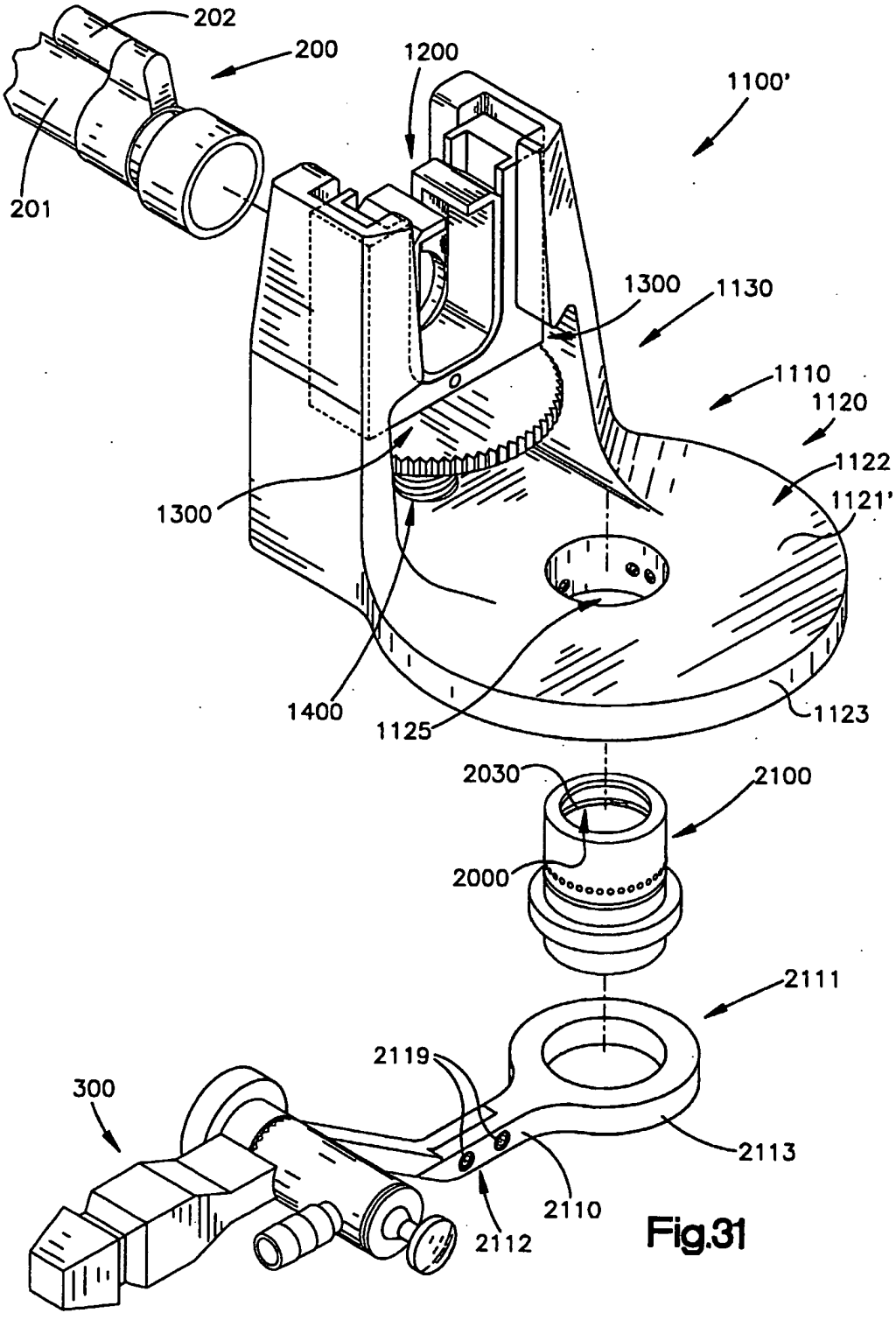

202
200
1200
1100'
201
1300
1130
1110
1120
1122
1121'
1300
1400
1125
1123
2030
2100
2000
2111
2119
300
2113
2110
2112

Fig.31

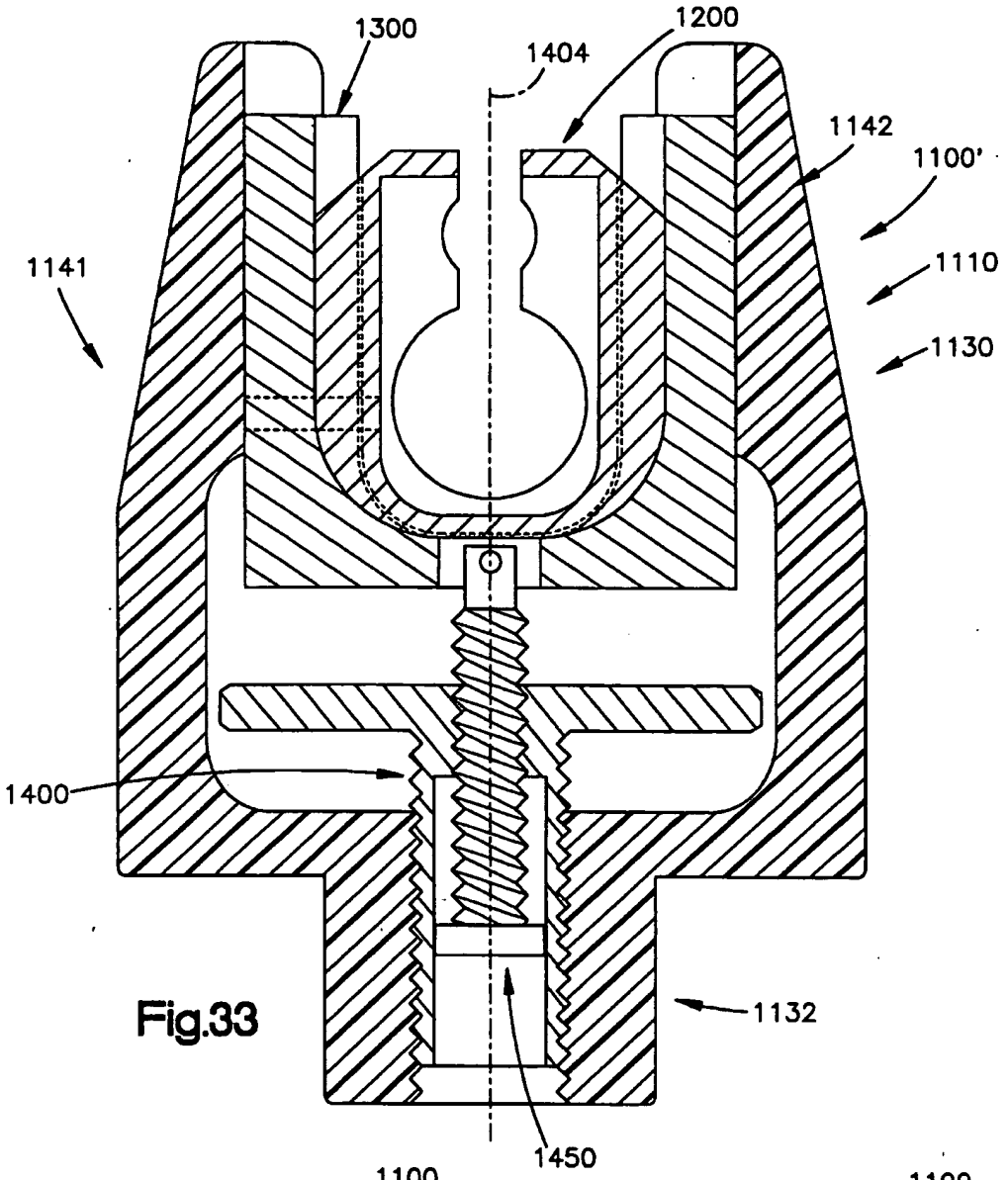


Fig.33

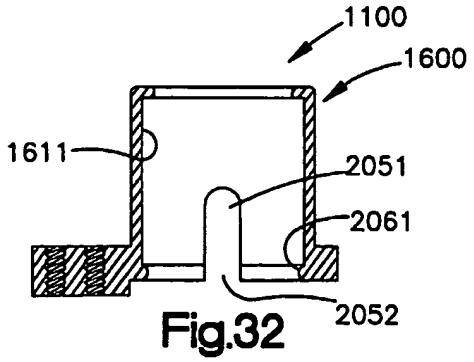


Fig.32

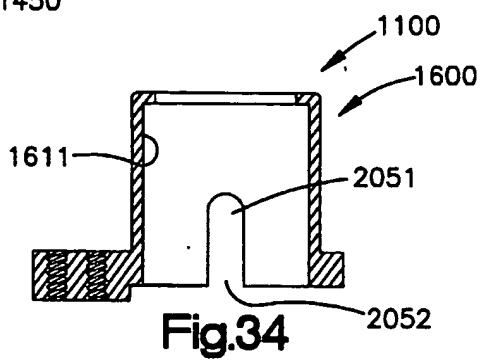


Fig.34

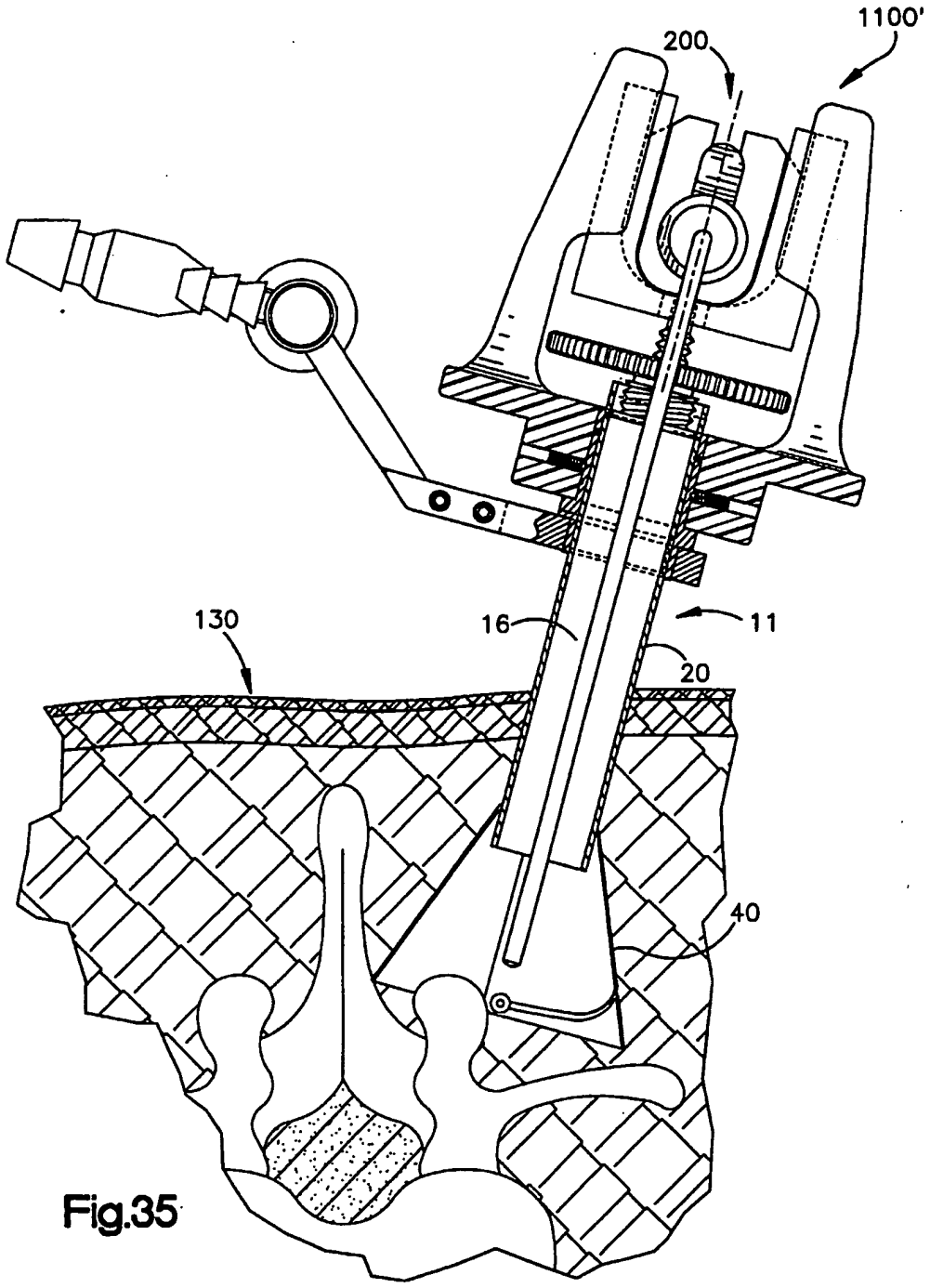


Fig.35